CREATING AN ENGINEERING ORGANIZATION FOR THE HEAVY PRESS PROGRAM OF THE UNITED STATES AIR FORCE

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A Lecture Delivered by

ALEXANDER ZEITLIN

President, Engineering Supervision Company

New York, N. Y.

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TELEPHONE: LUDLOW 4-070

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This course on "Case Problems in Engineering Management" which Mr. Kaiser and I have arranged, is designed to bring to the student the actual experiences of people skilled in the management of engineering projects. The first lecture by Alexander Zeitlin describes a successful and important engineering development - the Heavy Press program of the United States Air Force. We are fortunate to have a particularly talented speaker present the case.

Harold K. Work

Gentlemen:

Still somewhat embarrassed by the very flattering remarks made by Dr. Work on my behalf, I cannot but admire the perfect managerial performance: Management is most often defined as "getting results through efforts of others". Now Dr. Work has just pointed out that while he will be managing the course, Dr. Kaiser will be running it.

I hope that my report will indicate a performance at least half as good as this.

To facilitate the production of military and to a certain degree commercial aircraft, the design of aircraft must consider weight as one of the major problems and design for minimum weight is, of course, the aim to be kept constantly in mind. One of the ways of reducing the weight of structure is to reduce the number of joints and the quantity of the joining hardware to a minimum. Consequently, aircraft designers should always try to provide for large pieces. It is not necessary to burden the construction by joints and additional weight caused by them. Large configurations are desired. One of the best ways of producing them is by means of shaping the metal by plastic forming; - rolling or forging or extrusion or deep drawing.

Slide #1 — The first slide shows Fortune Magazine's idea of airplane parts and what forgings can do for them. You can see the basis structure of a piece, and how it was built up out of individual pieces with adjoining hardware in a conventional way before we had heavy presses. It shows also a design which could be produced on heavy presses.

The purpose of those heavy presses that we were building was to replace the composite structure by an integrally produced piece.

The first time the problem of broad utilization of integrally produced structural elements was encountered in this country was during President Roosevelt's program of 50,000 airplanes a year. At that time the B-17, B-24 B-29 required a tremendous amount of extrusions and the extrusion industry of this country consisted of 30 to 40 comparatively small extrusion presses - the largest being a 5200 ton press on order - not installed. The installed presses ranged from 1600 to 3850 tons capacity. During World War II, in order to resolve this production bottleneck, the Air Force sponsored, with the assistance of the press building industry, the construction of over 80 presses, which at that time were considered very large; the three largest presses were 5500 tons each.

Forging presses were not utilized in that program and the knowledge of the advantages of large forgings came to this country only on the basis of a study of some of the German airplanes that crashed in England, and then through the reports of the strategic bombing survey after the war. The investigating teams of the strategic bombing survey found in Germany presses up to 33,000 U.S. tons, while the largest forging press in this country at that time was 5000 tons.

Slide #2

Let me show you some examples of application of large forgings. Slide 2 shows a structure in its actual dimensions. The bulkhead of the XB-52, the experimental B-52, as you see it, consists of a large amount of individual pieces that are joined together by rivets and by welding. The size is indicated by the two persons standing next to it. This assembly could be replaced by two forgings made on a 50,000 ton press. Each

half could be forged in one piece. As you know the B-52 is practically obsolete. The general saying of the Air Force is that "if it flies it is obsolete" - so this is one of the examples that when it flies it is already obsolete, and I do not know whether this particular piece was finally made as a forging or not; but that was one of the pieces that was considered when the presses were built.

Slide #3

Slide 3 shows an assortment of pieces that the Wyman-Gordon Company was producing on the 18,000 ton press built in 1947/48 before the start of the heavy press program. You can see here an impeller for a jet engine -- there are some fuselage bulkheads - some landing gear parts and a crankcase. Those pieces are smaller than the bulkheads you have seen on the preceding slide. In order to give you some idea of what can be done on heavy presses, we can say that the forging of these pieces requires an effort of approximately 15 ton per square inch of the effective forging area. So in other words, the 50,000 ton press, which is a monster, can forge approximately 4000 square inches of effective forging area. 4,000 square inches effective forging area would be about three times the size of a standard desk. Of course, the cavities don't count. Consequently, an effective forging area of 4000 square inches may be distributed over a piece that is, (as some of these parts are), 30 feet long.

Slide #4

Slide 4 shows similar parts.

Slide #5

Here you see an imagination of a promotor of the heavy presses. This particular promotor - it was the Harvey Machine Company - dreamed up

this design of a fuselage structure for a fighter where all those structural pieces are either forgings or extrusions - and where the entire length of each forged piece is produced in one forging. There are no joints except where joints are essential for the construction. No plane of that kind has ever been built and I don't think that it ever will; still this slide gives you a good idea of the ultimate objective.

After the end of World War II, the long range planners of the United States Air Force realized that the availability of large forgings and heavy extrusions was a necessity if the Air Force equipment were to retain its leading position in the world. Therefore, it was decided, as a measure of improving the industrial defense potential, to start a new press program. This press program is the one that I am reporting on.

Let me first give you an idea of the magnitude of the task by showing you a few slides.

Slide #6

This is an artist's concept of a press made from the assembly drawing. You see the man standing next to the press? The portion below operating level is below ground. The rest is, of course, above ground. Credit for the concept of the press goes to the chief engineer of the organization. Remarkable on this press, as compared with the conventional design of presses, is the extreme simplicity of each part which is easily accessible to a thorough and strict stress analysis. There is only one item on this press, which I will show you later, which escapes a simple, practical, and I would say a more or less elementary, stress analysis which we had to test by making a model and stressing it to destruction in order to determine the stress distribution. Otherwise, all elements

of this structure are analyzable on paper. Of course, the size of these pieces is such that one doesn't feel too easy about analyzing it only on paper. However, some experimental stress analysis was done on this press. I will show you this later.

<u>Slide #7</u>

Slide 7 shows the tie rods of the 50,000 ton press. In order to give you an idea of the scale - those long tie rods are 108 feet long. The weight of the total press is 16,000 tons, which corresponds to the weight of the hull of a 35,000 ton battlecruiser. Its moving parts (the entire top moves down) weigh 8000 tons. At the end of the advance stroke the top has to be stopped within a rather short distance for accurate work. To undertake to design, construct, and erect this giant was quite a daring enterprise, considering that presses built in this country prior to this one had a rating of only 5000 tons with the exception of one 18,000 ton press which had just been completed at the time we were starting.

<u>Slide #8</u>

Slide 8 shows the actually completed and installed 35,000 ton press in operation. You can see how big it is - the part above the floor is 55 feet high. You see here each tie rod consisting of three plates - each finished lamination weighing 110 ton - which means 330 ton finished weight of each column. This is 2000 tons alone in the columns. Those pieces as you see are tremendous - they are all elegantly planned and easily analyzable in terms of stresses.

<u>Slide #9</u>

Slide 9 gives another indication of the magnitude of the project. This foundation

is 105 feet deep - requiring 130,000 cubic yards of excavation. 28,000 cubic yards of concrete were poured into this structure.

Slide #10 This is the Wyman-Gordon plant where the two forging presses are installed. The relation of the plant size to the presses is just about the same as the relation of the press size to the size of equipment of general run. The two presses were installed on the spot shown on the photograph as the open area where the foundations are being constructed. The rest of the building is the service area for those two presses and the third 18,000 ton press which is installed at the other end of the main bay. Inspection, heat treating, chipping, grinding, die sinking, and so on are arranged in the service building. The building area you see on the photograph is required to process the output of those two presses - so the two presses represent in themselves a key to the entire plant, which, as I mentioned before, required an investment of over $80 million of Government money. The total area of the plant is close to one million square feet.

Having given you an idea of the magnitude of the problem, I will now go on with the report on the project.

The project was started around 1949. The first orders were placed with us actually in 1950 and 1951. The project was started with a staff consisting of two persons - the general manager and his secretary.

Slide #11 Slide 11 shows how the organization developed over the period of the years during which the program was conducted. It started, as I said, with two persons. The build-up to about 20 men

was an initial program which was related to the heavy presses, but preceded the heavy press program we are talking about today. It is followed by the period of designing the heavy presses and from there starts another climb related to the manufacturing stage, setting up of the quality control organization and of the expediting, organizing the field offices to supervise the erection of the presses and to put them into operation, and so on - and here, finally, a period of steady work with the full size staff until here where the preliminary acceptances began to come through, and then here is the final acceptance.

Slide #12

Slide 12 shows the lead times for individual presses. Generally speaking, it took us from the time of the award to the preliminary acceptance of the individual presses from three and one-half to five years. The installation which was foremost in everybody's mind, the forging plant operated by Wyman-Gordon, required three years and five months from the date of the order till the preliminary acceptance; the final acceptance took place five years and two months after the order was received.

The extrusion plants which were to be operated, and are now operated, by the Kaiser Aluminum & Chemical Company in Halethorpe, Maryland; by the Harvey Machine Company on the West Coast and by Curtiss-Wright in Buffalo, New York, were accepted on a preliminary basis within from four to five years after the "go ahead". The final acceptance took place within five and one-half years to five years and nine months after the start.

Slide #13 Slide 13 will give you an idea of the rate at which the project was advancing and how the money was spent. You see here the progress chart for individual presses and for the total program. The total program is this black line - and I suggest that you just look at this line only. You see here the initial stage of development. It took about a year to start making real progress. I should mention that the progress as shown on this chart is measured in terms of money spent. It is very difficult tc measure the performance of an engineering group, or even a manufacturing group, on a large construction project in any other terms than either man hours invested or money spent. Money spent was chosen as a yardstick for many reasons, and here you see the initial stage where money was spent only slightly on engineering work and then here the manufacturing, the erecting and finally the project expending itself.

As to the amounts of money involved in the installations: for the Wyman-Gordon installation consisting of a 35,000 ton and a 50,000 ton forging press (the 50,000 ton forging press being the largest in the world) our direct share of the job was $33 million; the total cost of the plant close to $100 million, and for the three extrusion plants our direct responsibility was in the amount of $16 million. The total cost of the three extrusion plants were well in excess of $40 million.

Let's look now at the organizational chart as it evolved when the basic set up was completed.

Slide #14 Here you have the general manager and his assistant - here is the treasurer which has only functional access to the chief accountant but no administrative authority in the department.

Here is the bookkeeping - cost accounting, field auditing, statistics and reports. Of course, reports are an extremely important tool for the Management. Apart from all other uses of the reports, unless a system of reports is set up to give a true picture of performance, there is nothing in the organization that tells the general manager about his own performance. This is a very trying situation. I am sure that everybody who has been in the position of a general manager of an organization would appreciate just as much as I would an opportunity to hear some constructive criticism of his work. Unfortunately, very rarely is it heard from one's staff. Constructive criticism from outsiders is also not easily obtainable, so that the general manager has to place reliance on the setting up of some kind of a system of analysis of performance of the organization and then getting this analysis made by objective means, by a bookkeeper or a statistician, and have the appropriate report placed on his desk, looking at it regularly to see the reflection of his performance in figures.

Another very important department under the chief accountant is the field auditing, analyzing the bids and supervising the costs of all our sub-contractors in accordance with our duties as trustees and as consulting engineers for the agency that provided the money, the Air Materiel Command of the United States Air Force. You must realize that, although we were an engineering organization without its own manufacturing facilities, we were handling, as I mentioned before, over $60 million of procurement money and in the machinery which we installed, every single bit, down to the last bolt and nut, was procured and purchased from the outside.

Consequently, while we were supposed to be purely an engineering organization and nothing else, and all departments were only service departments for the basic engineering organization, we had to build them up and thoroughly refine their functions.

The Director of Procurement has the Purchasing Agent who negotiates the placing of an order, the manager of Sub-Contracting who finds the sources for manufacturing, and the Chief Production Engineer, responsible for Quality Control, Expediting and Manufacturing Methods. This again is something that will be rarely found in an engineering organization, but which we had to have because we realized that our problems of procuring those tremendous presses was a problem which was not only new to us, but to our sources in the manufacturing industry, too. For instance, the manufacturing of pieces like those tie rods I showed you before was something that had to be worked out and not every machine shop that had the machinery to produce those pieces was willing to invest either the machining time, or some of their brain in the project. Quite often, we had to develop the manufacturing methods and convey them to the manufacturers. We had, for instance, ingots out of which certain parts of the presses were made, 108 inches diameter, 26 feet long. Ingots of 108 inches diameter are nothing exhorbitant; actually the largest diameter of ingots made in the United States is 134 inches. However, the combination of 108 inches diameter and 26 feet length was overwhelming at that time and has not been exceeded today. We had to find a certain method of handling those ingots so that they would not cool down to a point where thermal stresses would crack the ingot

before it was forged. So, we had our own Production Engineering Department, which acted as Quality Control for our sub-contractors, help them whenever necessary with method development and processing. Since our Quality Control had to be taken into the plant of the sub-contractor, our quality control people also acted as our expediters.

Here is the Project Coordinator who handles, primarily, the field work, and also the supervision of the project progress in the home office, including the coordination between procurement, engineering, accounting, and so on. He is the one who knows first when the overall schedule is being delayed and he is supposed to cry "wolf".

The technical writers are people who took care of our technical information department. They would take care of our library, of evaluation of the literature, of providing information to us and channeling the information to our clients and to the Air Force and to prospective operators.

We come now to the core of the organization, the Engineering Department. As you see here on the chart, the top position in the department shows a blank. This odd arrangement will become clear to you in a minute.

Actually, two considerations are involved in this set-up.

The two major creative people in the organization were the Chief Engineer and the Chief Designer, who were (and still are) outstanding people. The Chief Engineer was the foremost press designer in the world. As you see, he as well as the Chief Designer, are kept completely free from

any administrative assignment: nobody reports to them. Of course, they were responsible for and were supervising the technical performance of the engineering staff, but they had no administrative responsibility and no administrative headaches so that they could devote their entire time to creative work.

The entire administrative responsibility and, consequently, the administrative authority rests with the Executive Engineer. The Executive Engineer must be a pretty good engineer himself but, of course, being burdened with the administration, he has no time to do any creative work. He must forego the professional satisfaction resulting from exercising his creative abilities and the company must forego the potential benefits of his creative work because somebody must take care of the administration of the department. So, the Executive Engineer must supervise the drafting room, bills of material, engineering scheduling, the reproduction room the archives, while the Chief Engineer and Chief Designer have only functional access to this in so far as it concerns the creative work and their concept of the design.

Reporting to the Executive Engineer are the Chief Industrial Engineer and the Chief Stress Analyst. The Chief Industrial Engineer has the structural group, the electrical group, the mechanical services, the equipment specifications for procurement. The Chief Stress Analyst is responsible for stress analysis and research to whatever extent we are doing the research, the material specifications and the coordination with our consultants.

The other reason for keeping this square in the Engineering Department set-up blank, is to bring the General Manager into direct contact with the three top men of the department and to give him an opportunity to evaluate all aspects of the engineering work at as early a moment as possible. Of course, he still is unable to get more than a birdseye view, but he has at least this.

Reviewing this chart once more, I can assure you that all the criteria which the theory of administrative management applies to an efficient chart are met. You can see on the chart that every function has been assigned to a definite unit of the organization; that the responsibility of each unit is defined; that no functions are assigned to more than one unit; that the functional set-up is uniformly applied so that the entire chart is based on one underlying organizational principle; that everybody knows to whom he reports and who reports to him; that we have no more than one person to whom anyone reports; that the number of people reporting to the General Manager or, on lower levels, to the individual department heads, is not excessive. The General Manager has only seven people reporting directly to him. He has additional direct contact with the Chief Industrial Engineer and with a couple of other guys, but this is for information purposes only.

<u>Slide #15</u>

Please don't think that the next slide you are going to see is meant as a joke. I admit there is deep irony in a situation when you work out a splendid organizational chart and then you are confronted with the situation shown on Slide 15, which indicates our relations to the Air Force. Of course,

they were our client, the client who was providing the money and responsible for its expenditure and who had, consequently, the right to say how he wanted to work with us. On top left you see the United States Air Force Headquarters in the Pentagon. Below is the Air Materiel Command, the procurement agency of the Air Force in Dayton, Ohio, and, representing this particular agency in dealing with us, is the Industrial Resources Division in Dayton. Then comes the plant office: considering the large amount of money we were spending on behalf of the Air Force, the Air Force stationed a plant representative on our premises. The officer in charge of the Plant Office was there and he had available to him the services of a Contracting Officer, an Auditor, a Quality Control man, an Expeditor, and a Property Accountant--- I believe that's all. The Air Materiel Command in Dayton had also direct contact with the field offices which were located in the plants where the equipment we would supply would be installed. Now, every one of those squares (excuse me for calling them squares) was absolutely determined to be in direct contact with every spot on our side of the chart-- and the major problem in our company was to keep the organization functioning without installing machine guns and without shooting the Air Force people on sight. That was a major load on the organization, so, while the organizational chart of the company is very nice and intelligent, the work with the Air Force completely over-shadowed our basic chart.

Here you see the General Manager with six or seven persons in the organization reporting to him,

but there he has eight men from the Air Force having direct access to him and you just couldn't get rid of them. The Chief Accountant had only four persons reporting to him and four Air Force men having access to him day or night, and I deliberately say day or night; all other people on the chart are in a similar situation. We could not change this condition but we tried to alleviate it and limit the contact of the individual people with the Air Force as much as possible. At two spots we made special provisions: we realized that the General Manager has to have some time left to manage the company; we also realized that the creative engineering work had to continue at as fast a pace as possible because the entire organization went into a state of suspended animation whenever creative engineering slowed down. We made, therefore, special arrangements for these two functions which helped us to see the project through much faster than we could have done otherwise. I do not claim that we saw it through fast; five years is an awfully long time for anything, even for a project like the heavy press program, but at least we eliminated the bottlenecks to the best of our ability.

So, as measure #1, we placed here next to the General Manager an assistant to the General Manager, and established the policy that the General Manager would not see anyone from the Air Force unless the person in question first saw the Assistant General Manager. As measure #2, two persons were forbidden to talk to the Air Force - those were the two people around whom the creative engineering was organized. Neither the chief engineer nor the chief designer had anything to do with the Air Force (or, as stated before, with any administrative problems). They were supposed to perform the major portion of the brain work of the organization and they were to be kept completely free from any interference, delay and annoyance.

1st Question
Period:

Question: The technical writers - did they report directly to the General Manager?

Answer: They actually reported to the Assistant General Manager. They had a clearly defined special task: this was an information office. In order to see that the information into the organization and out of the organization was channeled properly it had to be under the direct supervision of this office, the General Manager and Assistant General Manager. Otherwise we would have had too many slip-ups on policy problems.

Question: Did you say that anybody in the Air Force on the organizational chart could contact people in the plant?

Answer: No, he could not. I said they were determined to get through to everyone, but we wouldn't let them.

Question: Is there a difference between the Chief Designer and the Chief Engineer?

Answer: Well, the difference is actually only the prestige of the title. The Chief Engineer was really the foremost creative engineer of the organization. The Chief Designer, as his assistant, was getting separate assignments on his own and he had to be given some title, so he was called Chief Designer. It flattered his ego. He was a very sensitive man who always felt that people didn't appreciate his work sufficiently,

and he would get upset from time to time, so every time he would get exceptionally upset he would get either a pat on the back or a title.

We had a very nice skit one Christmas arranged, written and performed by the staff. One of the scenes was of a man coming to the personnel manager and complaining that he was not appreciated enough. In the skit, the personnel manager was telling him, "Well, --everybody gets one towel three times a week. To show you our appreciation from now on you will get a fresh towel every day, just like the General Manager." That flattered the man in the skit so much, that finally (still in the skit) the personnel manager would offer him, "Look, I will put you above the General Manager--I will give you two towels every day." The guy was so happy with two towels every day, that he agreed to take a cut in his salary. Please don't misunderstand me, the man in question is very good and extraordinarily gifted in his work; but those are the things you have to take into consideration when you deal with engineers. I, as General Manager of the organization, reported to the president and the then owner of the company. Whenever I would go the president to tell him how difficult it is to work with engineers, and that every engineer in my opinion equals two prima donnas, he would always comfort me by saying, "You should feel fortunate, if they were like you, then each of them would equal three prima donnas."

Question: Who was the third engineering executive and what was his function?

Answer: Here, the Executive Engineer. The Executive Engineer was the administrative manager of the department.

Question: In reference to the Chief Engineer and the Chief Designer, I was wondering if those men had the board men working for them?

Answer: Only in a functional manner. They would make the designs themselves on the board. They were creative designers who obviously would first produce the general layout or at least the concept themselves. They would make it and then the executive engineer upon consultation with them would assign the job of detailing, redesigning certain sub-assemblies, and so on, to a group leader in the department who would then work under the instructions of the Project Engineer, (either the Chief Engineer or the Chief Designer, or somebody else), but only functionally, not administratively. Only as far as creative work was concerned was the Chief Engineer or Chief Designer or any other project engineer authorized to give instructions. If he wanted a cylinder with a heavier flange - he would say I want a heavier flange - but he could not tell the man to work overtime, or give him a leave of absence or hire or fire anybody, or certify a time card. This was absolutely out of his hands. He was doing only one job-- thinking creatively on behalf of the organization.

Question: Are the three groups under the Executive Engineer grouped together because they have similar duties?

Answer: Yes, the Executive Engineer has reporting to

him the Chief of Stress Analysis, the Chief Industrial Engineer, and the Chief Draftsman.

Question: Does the Chief Engineer have people work with him while he makes a general layout?

Answer: No. This is purely creative work. The creative concept of an industrial machine cannot be put on paper by two men; it can be put on paper only by one man. So he has to work by himself - - to say, "Well, this is the press. I will make the upper crosshead this way; I will make the movable platen this way - this will be the lower platen; those will be the columns; the nuts will be this way; the cylinders will be inserted this way." Someone has to have these creative ideas before the filling in of details can be started.

Question: Did you have a special group to develop this program?

Answer: The group that developed this program was the Loewy Construction Company.

End of
1st Question
Period

We are talking about management, engineering management, management of an engineering organization and, therefore, I would like to say a few words about the philosophy underlying the way the organization was managed. Generally speaking, there are two basic assignments of the management: one is planning and making policy decisions, and the other is getting results through the efforts of others - through the efforts of the members of the organization. The first aspect - the planning and making decisions which establish the policy - was done originally (let us say, 100, 50, or 30 years ago) on a rather authoritative basis. The manager told everyone around and under him what to do and it was considered rather wasteful to have

discussions with subordinates. A good manager was brief and to the point. Now, the present tendency is getting away from this type of authoritative management and towards the consultative type of management by inviting your staff to participate in decisions with you and by your getting the benefit of their experience.

The first reason for the trend to this consultative management in our particular case (you realize that I am not called upon to give you the theory of management, but am only supposed to show you how we handled those problems in one particular organization) was my whole-hearted acceptance of this concept based, first of all, on the realization that I would be fortunate enough if I had enough brains to cover my own work; that I certainly did not have enough brains to think for a staff of 190 or 200 people. Everybody in the organization has to provide brains for himself and do a lot of thinking related to his own assignment. It would be ridiculous not to realize that my brains are not sufficient to cover all executive jobs:- my job as General Manager as well as the jobs of all the department heads reporting to me.

The second reason was that I was always firmly convinced that the staff with which I had the good fortune to work was well above average, and that those people with great experience and great intelligence, if they were allowed to help me, would always facilitate my job.

Now, the next thing is that the General Manager, especially with this Air Force situation, is working under heavy pressure. The time that he can devote to each problem is very limited, while the department heads who bring the problems to him, or who know about the problems well ahead of the General Manager, certainly have the opportunity to think about any particular problem for many many hours, if not many days and nights (if the problem is very troublesome, then probably mostly at night). So the problem is thought over, and whenever the General Manager is called upon to make a decision he can only benefit by getting the problem thinkers into his office and listening to their opinions. The responsibility for making

the final decision, or at least for approving the final decision, is his and this responsibility he cannot shirk, but making the decision without the advice of those people who had been brooding over the problems for many, many, hours and days is just silly.

So, I have always tried to get the decision made not by me personally, but by the executive staff of the company. Whenever a problem arose the people who had any association with it were called in; a conference attended by whoever was available would be held on the spot, and the people in the room were invited to exchange their opinions and try to arrive at some decision that was satisfactory to all of them, or at least to the majority.

The general manager would not express his opinion until the staff was through with their presentation and expression of their opinions so that they would not be under any moral or other pressure to say what they thought the general manager would like to hear.

Impatient people will say that this is a waste of time; that to spend so much time in consultation means that the manager just doesn't take care of his job. I disagree with that completely. First of all, decisions arrived at in a consultative way are usually well thought through; all aspects have been taken into consideration. You get the decision that is satisfactory to most people on the executive staff and, consequently, a decision that they will be able to carry out readily and willingly. In this way a precedent is created for the policy which is well understood by everyone and gives each one guidance for the future. This was our basic principle for getting results through efforts of others and it worked out very well.

2nd Question
Period

Question: What happens if a wrong decision is made?

Answer: The general manager is still responsible for that. A decision made in the general manager's office is the general manager's decision, regardless of whether he gets the advice and opinions of twenty men or no advice whatsoever. He is responsible for it and he has made the decision, even if his making the decision was only to say, "All right boys, I think you are wrong, but I'll let you go ahead with it." Often the reverse may happen; the boys may be told, "Well, you are all crazy and we cannot work that way, and for this and this reason we have to do just the opposite of what you unanimously think is right." That can happen, too. But, at least, you got the opinions of these people; you did get their willing cooperation, even if your decision is made against their advice. They know that their opinions are solicited and respected.

Question: In other words, you got the opinions of those people, but you would have to make the final decision yourself?

Answer: I would be responsible for the decision that comes out of the conference, not matter whether I made it or anyone else. To give you an example: we had a problem of quality control on big castings. The question arose as to whether we should magnaflux the large castings and whether, in addition, we should reflectoscope them by supersonic testing or not. The opinion of the large majority of the group was that we should not magnaflux them, nor should we re-

flectoscope them for the simple reason that every casting has voids and, if we started investigating all castings, we would run into a situation where every casting will be rejected and we will never get through with it. It went very much against the grain. But, I said, "All right, I will back you up. I will go along with you on the big castings that way." This decision resulted in a serious situation, so serious that we were near a catastrophe. First, the big platens of the 50,000 ton press were porous. Since no magnafluxing or reflectoscoping was done, we discovered the porosities only during machining. For six months we did nothing but boring and chipping out the cracks and voids. This was my fault. I accepted the staff's advice and I made the decision. The other similar problem occurred with the castings made in England. A more searching inspection would have discovered the faults in England and the castings would have been repaired there. So, they were brought over first and then repaired here during machining. The cost here was much higher and we had a problem in settling the back charges with the foundry.

Question: How long did it take to make a decision?

Answer: It depended entirely upon the case. Sometimes it took only one minute. Sometimes it took two days. Now, this decision on the castings took, oh, I would say, a one day's conference, but it was a basic decision. We had thousands of tons of large castings and we ran into some real arguments. The question was, "Shall we from now on magnaflux the castings or should we go ahead the way we did before"? This decision involved parts valued at maybe $5 million. It took a day. I don't think it is too much.

Question: Did you have periodic conferences, or did you handle each problem as it came up?

Answer: We had, once a week, a so-called scheduling conference in which we reviewed generally the progress of the work. Also at these sessions all pending problems were brought up. Otherwise, all problems were handled as they came up. No problem was delayed. The door of the general manager's office was always open and whoever had an urgent problem walked in and said, "Here, this is the problem. We must have a decision." For instance, if it was a question of quality control or expediting, the quality control engineer would come in and say, "Look, I have a problem here. I can't get any satisfaction out of Vendor #1. Vendor #2 machines a lamination in 2,000 hours and Vendor #1 takes 8,000 hours. I want to get tough with Vendor #1. Have you any objection"? The project coordinator, the chief of procurement, and the sub-contracting manager were called together with the Quality Control and Expediting Department and we decided on the spot what should be done. What was done in that particular case was that we stuck our head into a hornets nest. We went to Vendor #1 and told them that they did not know how to run their shop and, of course, the first thing was that Vendor #1 wrote to the Air Force complaining that we were libelous and guilty of defamation of character, and so on. However, they agreed to let us take them to the shop of Vendor #2 to show them the operations there. They went home and reduced the 8,000 hours to 2,500. Those decisions had to be made every day, and the manager must be prepared to make them the best way he can. I submit to you that the best way to do it is to enlist the cooperation and ready assistance of your staff by showing

them that their opinions are appreciated, and that their cooperation is solicited, not by indirectly telling them, "Look here, I have this position. Since I have it, I, by definition, must know more than all of you put together so, therefore, here is the decision. Go and carry it out, or else."

Question: Were the people consulted on these problems generally consultants or business contacts, or were they in the organization?

Answer: Of course, we used now and then the services of consultants on very special problems, but in general they were staff members whose work had direct contact with the problem. I mean, we would not call in the Engineering Department if it were a question of negotiations with a sub-contractor who was stubborn and would not accept the cost auditing clause. The Engineering Department has nothing to do with it. If the problem reached the point where we wanted to discard this sub-contractor and, if the Engineering Department would be happy with substitutes then we would call them in. Otherwise, we would call in the manager of Sub-Contracting, the chief cost accountant, the purchasing agent, and say to the boys, "Here, we have this company, it does not accept our standard boiler plate clauses which the Air Force insists we put into our purchase orders. What shall we do? Do you know any way of putting them straight? Shall we go to the Air Force and ask for relief in this case; ask them to forget this particular clause"?

Question: You said that the door to the general manager's office is always open and whenever a problem arose the person would just walk in and a conference was called.

Answer: Well, obviously, the majority of decisions, I would say about 90%, were made without conferences. In cases where problems really required some thinking and attention, the staff was called in and the problems discussed.

Question: The questions that I would like to ask - - did you find that by leaving your door open, people walked in with their problems the moment they arose, rather than think about them for at least a day?

Answer: Let me tell you: whenever anyone brought to me a problem that concerned him and asked me what he should do rather than tell me his intentions and ask for an approval, he was out of my office within half a minute. I would tell him, "Look you have been struggling with the problem and you have thought it over again and again and have come to me because the problem is really serious. If, after all this thinking, you have no idea of what you should do, but expect me within five minutes to give you a solution of your problem then either I am a superman, which I am not, or you are not so hot. So, you had better go back to your office and think it over and come back to me and tell me what you want to do. If you don't want to assume the responsibility because the decision is too important, that's fine. I will stick my neck out. You tell me what you want to do and I will tell you whether I approve it or whether I disapprove it, and I will be responsible for the final decision, but I will never, even if the solution is obvious, tell you what to do on the basis of a five minute conference when you had time to think about it for two days or two hours, or whatever it is." Remember, as a manager, you have to get results through efforts of others, so that you have to educate the others to apply these efforts. One of the things that they have to apply is brains. So, you have to educate them to think about their problems.

Question: What part did the assistant general manager play? Was he sitting in with you?

Answer: In most cases he sat in with me unless he had some special assignment. For instance, he was supposed to shield me from the Air Force whenever possible and so he would take the brunt. Whenever an Air Force deputation came and would say, "We want a conference, the job is going too slowly in Worcester; the contractor for the foundations objects to your method of engineering the foundation", then my assistant would first go and sit with the deputation and wear them out for four or five hours - then I would come in and give them the mercy kill.

Question: Did you confine your contacts to department heads, or did some of the lower level people come into your office?

Answer: I have shown on the organizational chart dotted lines indicating that there were certain people in the organization who had direct contact with the general manager. However, in this respect, the instructions given in writing and verbally were very emphatic. In no circumstance was it the general manager's intention to consciously give orders or instructions to anyone who did not report directly to him, but reported to an intermediate level. Should ever the impression be created that the general manager was giving orders over the head of the proper supervisor, the person in question was expected to call the general manager's attention to it and question the propriety of giving orders by bypassing the proper supervisor. We had a very firm rule that information contact was free throughout the organization, but instructions, orders and policy were

given only through the people in proper functional order, and I carried this out to the point where I expected the same from the president of the company with regard to my job. I told the president that, should he give orders over my head to any member of the staff who reported to me and that, should I find any one of my men following his orders which were counter to mine, I will fire the man, not for taking orders from the president, but for lying to me by saying that he had received such orders, since I was certain that the president would not break the organizational rules. So, if a man were to tell me that he had been given orders by the president, I would fire him for being a liar. I had no contract with the company, the president could fire me any day, but,as long as I was there I wanted the organization to work properly and in the way I felt the organization should work.

Question: Was the project coordinator on your staff, or was he with the Air Force?

Answer: No, on ours. This whole picture on Slide 14 is our organization. The Air Force is shown on the left on Slide 15. The project coordinator was our man and he saw to it that the engineering was done more or less on schedule, and that the procurement was done more or less on schedule, and so on; also that any problems or questions be resolved at the earliest possible moment.

Question: Was the executive engineer or the chief project coordinator responsible for the climbing costs?

Answer: Costs of the project are a very sad story. We over-ran the original estimate of the job considerably. The job was estimated before the Korean War and it was completed during and after the Korean War so that, of course, the costs ran way up. The

main responsibility of the executive engineer and of the project coordinator was for the proper performance of their departments. The question of cost was supervised and handled by the general manager, the assistant to the general manager, and the chief accountant. We reviewed the costs and discussed them with the department heads.

Question: Did you have any conflicts between the executive engineer and the chief project coordinator?

Answer: No, never. Their functions are entirely different. The project coordinator has no engineering authority. He only sees to it that the drawings go out from the Engineering Department to the Purchasing Department, or that the drawings go to the field office, and so on. It is a purely administrative function that sees to it that everyone is kept informed and that the information travels through the proper channels.

Question: I have two questions. First, was a memorandum formed and was any record kept of the problems and the decisions that were made?

Answer: If the decisions were of a permanent value, if they were policy decisions that would have to be followed through in the future, a memorandum was prepared.

Question: My other question is with regard to any lateral connections between your departments. There seems to be an obvious connection such as, for instance, your industrial engineer and your procurement engineer. Your technical writers are in here - I have not seen any lateral connection to them in your organization.

Answer: It is difficult to put on paper the lateral connections in an engineering organization because, actually, in an organization working as a team, the mutual access for the purpose of information should be free, and we have kept it free. We have not limited the access of one department to the information available in the other department. We have certainly limited the right of people to give orders or instructions, or to make demands, but, as far as information is concerned, the contact is entirely free.

Question: In the design of the press, if the chief engineer or the chief designer conceived a new type of press, would he give it to the chief industrial engineer who would pass it on to the structural. mechanical, and electrical group?

Answer: No. The chief industrial engineer actually engineers the auxiliaries only. In other words, the foundations, the building, the mechanical services for the building, electrical services in the building or around the press. The press proper has nothing to do with the industrial engineer. It is between the chief designer and/or the chief engineer, and the executive engineer and his staff.

Question: Then these two men would have functional jurisdiction over the department.

Answer: Yes, they would have functional jurisdiction, but not administrative jurisdiction. In other words, they would give instructions on what should be put on paper, but not how a man should work nor what his working hours would be, nor certify his time card, nor handle any other administrative problems.

Question: If they had one person, let us say in the structural group to whom they had explained a problem and spent several hours with, and then because of some other breach of program he is to be fired, could they stop this in any way?

Answer: We have fired very few people. We were very fortunate in having an outstanding staff, so this question arose very rarely. Usually, people were not fired on the spur of the moment. If they were laid off,there were good reasons for that which were primarily non-performance or lack of intelligence.

Question: You said that your chief engineer and chief designer have no jurisdiction over overtime, etc. Who set the pace in engineering work?

Answer: We talked about the general assignments of a general manager and those are planning, making decisions and establishing policy. Now, "getting work done" we have not yet covered. If you wait until I give you a report on this, maybe some of those questions will be answered.

Question: I would like to know why a separate division was set up to undertake this heavy press program rather than to be undertaken as part of the normal work.

Answer: At the start of the project, Loewy Construction Company was non-existent. Hydropress was in existence. That was the parent company of Loewy Construction Company. However, the staff of Hydropress was busy and had the assignment of continuing the regular work of the organization which was design, supervision of construction and supply of presses of human size. The Heavy Press Program was a project of magnitude of close to

$5 hundred million. Although our orders were close to 60 only, the total cost of installations into which our equipment was going was close to $500 million. Actually, a year after we started setting up the organization, the Government came and confirmed that they wouldn't let us do it any other way, that we must have an entirely independent set-up for this program. The organization that we developed proved to be rather stable. It is still in existence and a good group of engineers continue to work quite successfully in many fields of industrial and design engineering. We created something that survived the program, but the first objective was the program.

Question: All these channels you had with the Air Force, they were primarily an exchange of information - they were not authoritative in any way?

Answer: They would come and they would try to give orders. We resisted them. Of course, if the Air Force Quality Control man comes and says, "You have accepted this piece and I think it should be rejected, and I demand that you reject it", we would first reason with him and see what his arguments were and then, finally, if it really came to an impasse, we would stand our ground if we felt that we were right. We would say, "You can take the job away from us, but you cannot let us have the responsibility and not have the authority." In the entire organization, responsibility was matched by the proper authority and we kept it the same with the Air Force. We were the people who were entrusted with the job, we had the responsibility for the job, we had to have the authority to run it.

End of 2nd
Question Period

I would like to turn now to the second aspect of management function. That is, how do you get work out of other people? Now, you can, of course, get work out of them by intimidation and force, and that was done very efficiently on the old galleys. Swinging the whip over the galley slaves got work out of them and apparently the galleys moved pretty fast, but we do not feel this method is applicable today, although there are still organizations, even engineering organizations, that are run by force and fear. There is a possibility of running a job and getting results out of others by impressing people with the authority of your position and demanding that they perform in accordance with the standards and instructions you set for them. We always felt, (and the success that we had in Loewy Construction Company and that we now have in Engineering Supervision Company, I think, is due to this concept of work) that the best possibility of getting results is by creating a feeling of satisfaction in the staff. Satisfaction with the value of their own good performance. If we can get the satisfaction developed to the point where they begin to think of the need to produce results as their very own problem, not a problem that is imposed on them by dictation or by the authority of the General Manager; when they get results because they think it is important for <u>them</u> to get results, that is the point at which the management really can feel satisfaction in its own performance, just as the men will feel satisfaction in <u>their</u> performance. Once you accomplish this and once you sow in the minds of the staff the conviction that it is important for their <u>own</u> peace of mind and soul to perform well, then the managing of the staff becomes not a task but really an enjoyment of the job you have. Then you can devote your attention to many other problems.

Now, how can you accomplish this spirit in the organization so that everyone feels satisfaction from his own and the team's good performance?

First of all, you yourself have to place the highest possible value on human relations. You must have an approach to human relations that makes it close or equal to a really profound religious belief and apply it in daily life.

Second, you must realize that every individual has a very high and unique worth of his own; that every individual is a special being with his own unique features, his unique values; his unique contribution which is not duplicated by anyone else and cannot be measured in terms of comparison with anyone else. You must realize yourself and convey to the organization the realization that, while the responsibilities of the staff on various levels of the organization are different, those differences mean very little as compared with this basic worth of each human being. While the jobs on higher levels may carry more responsibility and give more authority and more remuneration --if you can convey to your staff the conviction that <u>no</u> job in the organization can be eliminated without an irreparable damage to the whole group and that every job in the organization carries its own dignity regardless of the level of responsibility, authority and remuneration, then you will have a staff that can cooperate with each other and does not need any authoritarian approach or approach by intimidation or force.

Please don't misunderstand me, I do not suggest that everybody should be treated equally. A few years ago we had an ASME management conference which had ethics in business as its topic. One of the discussions was ethics in relations between management and labor. Those meetings, the so-called Skytop Conferences are conducted by having a panel present the problem at the beginning - four men, each ten minutes - followed by a free-for-all, off the record, discussion. In this particular session, which was very, very vivid and attended by everyone, several speakers in succession mentioned the golden rule - and the meaning of it as applied to the relations between labor and management. They kept repeating "don't do to others what you don't want to be done unto you", and "do to others what you would like to have done unto you". Finally, after an hour of this type of discussion, practically everyone in the room was subscribing to the golden rule in relation between management and labor; out of one hundred people only five disagreed. Those five, however, finally changed the opinion of the majority by pointing out that the management cannot apply to the labor the golden rule, and that it is unfair to both sides to expect the application of the golden

rule in this case. At that time the discussion was primarily on security and opportunity. Obviously, management, the higher you go, puts more and more value on opportunity. Labor, in general, puts more and more value on security. Now, you cannot tell labor - I want opportunity - so you have to be satisfied with opportunity and to hell with your security because I am not particularly interested in it. You have to approach this problem on a much higher level than the ethics of the golden rule. You must look at what is important to the other fellow - not to treat everybody alike and just say, well I want this - so everyone in the organization should be satisfied with my treating them the way I would like to be treated. You have to treat each level of the organization and each person in a way that is most satisfactory to <u>him</u> so that you get the best out of him by providing conditions in which <u>he</u> can work best. To tell an ozalid machine operator that he has all the opportunity before him up to and including the general manager's position is silly. He wants his pay every week and he wants to be assured of it. He wants to make as much overtime as you will let him get away with, and you have to create in him the feeling of job security.

Now, to tell an efficient department head that he is secure in his position is not enough. You have to show him that if his ability matches his ambition, he will get ahead and some day he will be the general manager and take over your job provided he will perform satisfactorily; in other words, provided his ability matches his ambition. This differential treatment is the right one and the one that gets results out of the staff.

Another principle which is very important and which the organization must understand and apply with you, is the problem of - what I may call - intellectual integrity. You must be able as a manager to evaluate your and the organization's performance. No one can be completely objective - but at least try to be as objective as possible. This especially applies to managers of engineering organizations and to engineering executives on various levels. If you have an engineering problem which you

handle, let us say a research project, you must be able at any time to evaluate the progress of the project, and if you come to the conclusion that the project is a mistake, then you should have enough guts to stop any project and say - "well, we made a mistake and we are stopping the project" - rather than continue the project and deceive yourself and the organization and everyone in it and around it. This is an extremely important point.

Once you begin trying to approach your own problems as objectively as possible, and once you recognize the intrinsic worth of every human being and every associate of yours, you come inevitably to the conclusion that authority in technical problems works only insofar as the assumption of responsibility goes, and you will come to the conclusion that one will listen to authorities because he knows they are experienced and respects them because of this, but you will not expect blind acceptance of authoritative decisions whether made by the chief designer or by anyone from the outside. You will not accept statements, regardless by whom they are made - by Timoshenko on Stress Analysis or by someone else in another field - just because they are made by a big name. You will analyze them and you will come to your own conclusion as to whether they are correct in your particular application or not. Once you start claiming this right for yourself, you will grant this right to your entire staff; it has been our principle - and it has been carried out throughout the organization, - that no engineering associate of the company, regardless of whether he is a draftsman or a chief engineer, had the right to refuse to his associates or to his subordinates an explanation of a decision, or an opportunity to argue it out with him. As I said before, it is my sincere opinion, that we had the foremost designer in the world, still from time to time we took objection to his engineering decisions. He was a big enough man to take it gracefully, and thus set an example to everybody in the organization. We would have carried out the policy regardless of how he would have taken it, but it was, of course, a great satisfaction that there was no problem or friction. His staff, or the stress analysts or the general manager, from time to time, would feel free to discuss or

even argue with him on individual problems and we would always arrive at a decision satisfactory to all - but never would we take anything for granted or bow to an authority, blindly.

I have now a couple of slides where I will show you how this principle of not taking anything for granted in engineering problems works out. This is a very important point. Respect for a questioning approach on the part of your staff, regardless of the level they work on, is a prerequisite for the creation of a viable engineering organization.

On the next couple of slides I have some examples on engineering, production, transportation, foundation and on erection problems. I will just cover them briefly by demonstrating the size of the problems and how we tried to solve them.

<u>Slide #16</u> This slide shows the fracture of a heavy cylindrical tie rod in a press of a conventional design. This is a tie rod of an 18,000 ton press. In selecting for our forging presses a design of extreme simplicity of individual parts we wanted to avoid situations like this where stress analysis, as it was known at the time the presses were designed, was insufficiently developed and insufficiently applied to avoid fatigue failures of the type shown.

I am sure that if you are sufficiently interested and you walk over some day to Dr. Gerard's and Mr. Becker's laboratory, they will show you the study we made on this problem last year. It is solved now, but in 1948-1949 rather than trying to solve this problem, we eliminated it by using simple parts.

<u>Slide #17</u> Here you have an example of a correction introduced into the work of the chief engineer by the Stress Analysis Department. This is a design

of a long lamination for the tie rod as it was originally conceived by the chief engineer and, when the design was questioned, we discussed it with him and we agreed that we would make a thorough photoelastic stress analysis. As you see here, the stress analysis disclosed tremendous stress concentrations at the point where the hammer head of the lamination rests on its support at the corner. Well, we continued to modify and analyze it photoelastically and through modification of the design we arrived at -- the next slide--the design that is entirely different and which eliminates those stress concentrations. As you see here, the tie rod is supported not by a wedge, but by those semi-cylindrical supports with clearance; as the tie rod elongates, it wraps itself around the cylindrical support and the stress concentrations at the edge of the contact are eliminated because the edge continues to shift. This shows you the value of team work, the value of taking nothing for granted, not bowing before the greatest authority that we knew, but checking and finding out what the facts really were.

Slide #18

Slide #19

This is an example of destructive testing. I mentioned to you that one part in the press was of such a complicated nature that we could not analyze it any other way except by destructive testing. Today, we probably would not make a destructive testing, but we would probably build a tri-dimensional photoelastic model. But here you see those strain gauges where the stresses were measured. This casting made of aluminum was tested to destruction on a 300,000 lb. machine at the University of Illinois. We determined the stresses and the casting was properly designed. It performs very well today.

The part in question is a cradle for a cylinder. It transfers the stresses from the hydraulic cylinder onto the cylinder support.

Slide #20 — This is to demonstrate the size of the problem requiring new engineering concepts. The extrusion billet is put into this container, then brought by the pressing stem into plastic state and extruded through the die; this container has to resist the pressures in the billet.

Slide #21 — This slide shows the stress distribution of this compound tube. You see that the tube is made of three parts shrunk together and these portions here are stressed above the elastic limit. One portion of the container is actually in plastic state and does not flow only because it is held together by the rest of the metal which is elastically stressed.

Those problems had to be analyzed. It was a new approach. No one, before the Heavy Press Program went into action, had designed extrusion billet containers with partially plastic walls. We did, and we have proved that, when properly applied, this concept works.

Slide #22 — This is an example of production problems. This is a tremendous ingot 108 inches diameter, 26 foot long. It weighs close to 250 tons.

Slide #23 — Slide 23 shows you how this ingot was forged. We could not let it cool down. We had to take it while it still was red hot from the original heat and forge it into this rough lamination (Slide #24) which later on was machined into the finished state which you saw before.

All these operations had to be devised by us and sold to the industry. I always felt, and I feel so today, that the manufacture of these long laminations was not half as difficult as convincing the industry that they could and should make them. It took us six months to sell one company this idea; once they started - there was no problem.

Slide #25 Now here is another problem which we encountered and which we had to resolve, that is a 100% weld in a 12" thick plate about 42 feet long. The test core taken out of it was made into a metallurgical specimen. Here you can see the weld which is perfectly sound. We had to set up a special manufacturing facility for that purpose. That was one of the problems the organization had to solve and did solve quite satisfactorily.

Slide #26 This is a problem in transportation. Here is a 108 foot long lamination to be transported on railroad from Bethlehem to South Charleston, West Virginia, then from Charleston, West Virginia to Worcester, Massachusetts. The car on which this tie rod is moving is much shorter than the lamination. Two more flat cars were added just to join the flat car which this piece is over-hanging to the rest of the train. We had to design the flat cars and everything else involved.

We had to check every single curve in the railroad, every single bridge and tunnel.

Slide #27 Here is a casting (Slide #27). This casting was made in England because the facilities of American foundries were tied up with the Korean War, and we had to make quite a few castings in England, in France, in Italy

and in Japan. This particular casting is of personal interest to me because it was made in Sheffield, England, and when transported to the port it damaged the main bridge in the city of Sheffield. The bridge sank six inches into the ground, and the Sheffield papers were full of articles calling the Americans names, arbitrary, and everything else under the sun. Apparently, they did not know the Ministry of Transport had given us permission to use the bridge. Then a couple of years later, I was presenting a paper on the technical aspects of the Heavy Presses in England, and I had only one consolation for the people of Sheffield and that was that when the casting was brought to the United States we broke three of the Pennsylvania Railroad's cars before we delivered it to the site.

This casting weighs 180 ton. It is 24 feet wide and 35 feet long and it was terribly clumsy to transport, as you can see. This is a half of the bed of the 35,000 ton press with the rectangular recesses for the two columns.

Slide #28

This is to show you the magnitude of the problem with the foundations. The foundations had to be placed in a certain spot in the building complex and on this spot, before we started the foundation work, a brook was flowing and the ground (fine silt) was soaked with water. It held the water like a sponge. Deep wells didn't work. We had to put well points - about 1300 well points - to remove the water (over 3 million gallons in every 24 hours) and those well points are all around. With those conditions we had to go down 105 feet to set up this foundation.

Slide #29 This is another problem of erection. We had those 108 foot long laminations which have to hang into the press. The original timetable of our field engineering group in the field showed that it would take them a week to put each lamination in, and we have on the 50,000 ton press six columns with three laminations to a column, or altogether 18 laminations. So they figured 18 weeks just to put the laminations in and we said it just wouldn't work; we wouldn't agree to that schedule. Well, we had the model of the press and we got the erection people and our field personnel into New York together. We ordered them to play with the model and with the erection rehearsal for days and days. After a week they became so bored with it they couldn't see the model any more. Then we sent them back and the first lamination took them three days; the second lamination took them two hours, and from then on they hung each lamination in less than half-an-hour. So this rehearsal on models pays, definitely. We were determined to get them to the point where they would be able to do it blind-folded, just as a soldier dismantling and putting together a machine gun is supposed to do, blind-folded. We told them that they should know the job so that there would be no problems any more. This rehearsal worked. We finished the job in less than four weeks - those 18 laminations.

Gentlemen; I hope I have given you some idea of how we created the organization and how we managed it through the job. As I said before, the organization continues to work and prosper and does a pretty good job, so it is a great satisfaction to me, as one of the people who organized the group, that it proves to be capable of survival.

Thank you very much for your attention.

<u>3rd Question Period</u>

Question: In this problem of management and relationship, you said that you treated everyone as an individual, but as a general manager how low in the chain of command, you might say, do you associate with these people? Do you just associate with the immediate staff, or do you get down to, maybe, draftsmen?

Answer: First of all, the general manager's office is open to anyone who has any personal problems which he wants to discuss with the general manager. If a person feels that he has a personal problem on which the general manager can be of assistance, then the general manager would see him regardless of the level in the organization.

Second, obviously, as I said before, orders are given only through the proper channels, but a personal acquaintance with the job and performance of as many people in the organization as possible is essential. In other words, the general manager has to spend some time in

going through the organization and meeting everyone on the job and learning how the particular person performs his job, and showing the person that the general manager considers his job just as important as any other job in the organization. The general manager can assure a particular person that whatever problems the job presents he will take care of, not by giving him instructions or giving him permission to do it this or that way, but listening to his story and discussing it with him and then putting any necessary changes through the channels.

Question: How did you go about securing the high quality of the technical personnel for your organization? At the present time many organizations have trouble getting people at all and you seem to have succeeded in getting a very high quality of personnel.

Answer: Well, we just looked around very diligently until we found the right people. Once we established this principle of looking for high calibre people; once this knowledge spread through the engineering community of the city, we had applications and visits from people who were reasonably certain that they would meet our requirements and among those we made the necessary choice. There is no hard and fast rule in that respect, but we applied some new approaches to the problem. For instance, the senior members of the staff spoke quote often at engineering societies. Whenever possible, we would mention that we were looking for intelligent associates. Of course, the personnel manager was well aware of the requirements that the organization placed on new personnel and he was looking for this wherever he could,

either by advertising through personal acquaintances, asking the staff to look among their friends, and so on. Of course, your success in hiring depends on whether you know what you want. Our policy was that in hiring people, the first qualification in respect to which the personnel manager had to satisfy himself was: does the person have enough brains to perform not only the assignment that is scheduled for him, but to advance in the organizatinn? We could be desperately in need of people, but we would not compromise on this item; intelligence and brains was the first requirement. Experience was obviously also required, but we would compromise and make allowances and be satisfied with less experience but not with less intelligence or ability and desire to advance.

Question: Did you feel that you had to pay more, did you have to pay higher salaries than what persons were getting on this present job, or was there any other attraction when hiring people?

Answer: We have never bought personnel by offering them more than they were receiving on their present job, just because we wanted to hire them away. We evaluated what we would expect from the man and we would offer him what we had set as standard for this position. Sometimes it was higher, sometimes it was lower, sometimes it was the same as in his present position. Quite a few persons joined our staff without any increase, even with taking a slight minus difference, because they felt that the climate was such that they would feel happy in our organization. We do the same today and we have acquired a good staff in Engineering Supervision Company in the same way.

Question: The set-up of your engineering department was unconventional, as you have said. Was this done because you felt it suited your organization better, or was it tailor-made for the people involved?

Answer: Well, of course, it started with a tailor-made set-up for the people who were involved and for the evaluation of their abilities and performance. However, once it was made, it was so successful that we felt it was a good principle. It is actually too much for one man to be an outstanding creative engineer and, at the same time, an outstanding administrator. In addition to that, and apart from that, it is too much to expect a man to pay attention to those two completely different aspects. I used to be a useful member of the human race, I used to be a research engineer and I think this is a most thrilling and most interesting and most productive activity that one can have. This is my personal opinion. I hope that Dr. Work and Dr. Ge and a couple of other people here share it, but once you become an engineering executive you mus be prepared to stay away from creative engineerin because you will never be able, it if is a full time administrative job, to do justice to your administra job and at the same time do creative engineering. It is a very hard decision, it was hard for me to drop creative engineering in favor of administratio and I would not impose it on people who are capabl of making a very substantial creative contribution. I would try to preserve for them that freedom fron being busy with paper shuffling and red tape. In setting up any engineering organization, I would follow today fundamentally the same principle: to keep creative people out of the chain of administrative authority. I realize, of course, th in a conventional set-up of businesses the higher remuneration is combined with the greater admini tive authority. We have to look for ways and mea

of correcting this situation and giving sufficient and adequate compensation to creative people, but not by burdening them with administrative work.

Question: So, the man who has the administrative authority is a man whose special skill is one of managing and yet he is called upon to make, at times, engineering decisions. He may have, of course, advise from the chief designer or the chief engineer, but there will be a problem and I wonder how you solve it. The only way he could do the managing is to have some knowledge on his own perhaps.

Answer: Yes, that is a problem. The manager has to live with it and has to make the best of it and carry the responsibility the best he can - the best, probably, would be to confine himself to administration.

Question: In your personnel policy you mentioned the importance of the ability of an individual to grow and progress within the company. Now, if your company built up to about three or four times its size within three or four years, does your expansion occur primarily at the bottom to include the people who joined the company in 1950, 1951 and up?

Answer: I would say that the majority of the people within the company did advance, and that proper opportunity was given to all.

Question: When you prepared your cost estimates for bids to the job, whenever they were prepared, I didn't see any organization in your company to prepare cost estimates.

Answer: No, speaking about the creation of an engineering organization we did not cover the problem of sales

and cost estimates for sales proposals. Actually, this was done by a separate group in the Sales Department -- so it was not shown here at all.

Question: Did you require any special training programs?

Answer: We have given the people within the organization as much training as they could stand. We were ready to indoctrinate them twenty-four hours a day, seven days a week. You must realize, this problem, as Dr. Work mentioned, was a new problem. We did not have people experienced in heavy presses, except two or three, and we had to train the group and the organization as such, train it to approach, analyze, and solve engineering problems of unprecedented magnitude without much background and do it with basic engineering as the only foundation. So we were willing to train the people and we did train them.

Question: How were they trained? In class?

Answer: No class training. The training was done in the greater part within the department by pointing out the problems and showing the solutions of the problems; by recommending studies; by giving time off to people who attended schools; if a man went to night school, we would see to it that he would not be sent out travelling on nights when he had courses, etc., etc. On any technical questions that he would bring up, someone in the organization would take the time and trouble to talk to him. We have welcomed anyone's writing a Master's or a Doctor's thesis in connection with our work. We have not restricted the information in that respect.

Question: Who actually rated the work of the men?

Answer: The rating of men was done by two persons, first of all by his immediate administrative supervisor. The rating was done every three months; a special form prepared for this purpose had the objective of primarily helping the supervisor to produce as objective an evaluation as possible. You cannot eliminate personal likes or dislikes. Nobody can be absolutely objective, but you can help a man to try to be objective by setting up a form that would give him an opportunity to catch himself on any emotions that are involved in his evaluation of the particular person; by setting up questions and forms, letting him rate separately the quality of performance, the quantity, the cooperative attitude with regard to his supervisor, his interest in the job - putting all those questions separately and in such a way that the person who rates would think twice before succumbing to his own emotions. The second identical form was filled out by the personnel manager; if we found great discrepancies between the two evaluations, we would sit down wit the supervisor and the personnel manager and try resolve it: What was the problem? Did the persor manager miss the point, or did the supervisor favc or, on the contrary, gun for that particular man? In most cases we could keep the situation under control and get a satisfactory evaluation.

Question: You said you exceeded the budget of the program. Is this due to the change in the original requireme or due to a wrong estimate?

Answer: It was due to the long lead time and also to the fact that when we started the job we, fortunately, did not know what we were getting into. If we had

known all the problems at the beginning, all the headaches and difficulties we would encounter on the job, probably everyone of us would have run away from it. At the beginning, as I said, I was alone with my secretary...we started getting the staff together and, if I had an inkling of all the problems in advance, I would probably say - "Well, there are so many easier ways of making a living, I had better go back into research and forget administration." But, fortunately, all those problems arose one at a time. Let's say, not more than 100 a day-- so you live through them little by little; then, when you go ahead, you find out that new ones have popped up. Here we thought, we would make long laminations out of rolled plate - 13 laminations to a column, each lamination being fabricated from 3-1/2" thick, and that they would be rolled by Lukens on their long plate mills. In order to roll those laminations the length we needed (108 feet) Lukens would have to move some auxiliary equipment which in 1949 and 1948, when there was a slight recession or readjustment, whatever you want to call it, Lukens was very eager to do. In 1950 the Korean War started. We came in the Fall of 1950 and Lukens said - "Get out of here - forget it." So, no rolled plate -- nobody else can roll the long plate. To make it out of three pieces - the center piece and then the two hammer heads and weld - well, we didn't know enough about 100% welding of heavy material at that time. We were afraid of doing it. So the next best solution - let's make it forgings. We knew that ingots up to 250 tons could be cast and forged, so we decided that three laminations 13 inches thick would give us the same 40" x 40", 1600 square inches which we needed.

I started visiting our vendor on this item in August, 1950. In the first six months there were wonderful lunches in the executive dining room, but no forgings. Once a week I was fed by the vendor until, finally, in March 1951, I said, "Now look,

today was the funeral lunch. Either we do something or not; but I am not coming anymore. Life is too short to do it. If you don't do it --and you in this country are the best people to do it, I am going to try to get the forgings abroad". Well, they didn't want us to go abroad, so they said, "allright, let's start discussing it". So they began discussing it six months after I brought them the job, another three months passed and they finally said, "Allright, we will try but you know we will require so and so many re-heats, so and so many forging hours and so on, it will be rather expensive". "The first lamination, maybe" was the way they put it but then after the first lamination was finished, it was so much simpler, it wasn't even funny. So, the main trouble with those laminations was to negotiate with the vendor, not to make them.

Question: On these costs there must have been an estimate of some kind indicating the cost of X million dol[illegible] How did it relate to the final figure?

Answer: The final figure was much higher. New problem[illegible] new costs were arising everyday. The forged laminations, for instance, require machining of the long plate -- the rolled plate would not have to be machined all the way and, in addition, we had the increase in cost from 1949: the pres[illegible] were finished in 1955. You must figure that ove[illegible] the period of the last three, four or five years the increase in cost of the "conventional" heavy industrial equipment is about 8% per year. On the super-heavy equipment it is still higher. Th[illegible] is a devaluation of the dollar value in terms of heavy industrial equipment.

Question: Would you have organized differently if it were not a CPFF contract?

Answer: We couldn't have handled it if it had not been a C[illegible]

contract, We did not have a complete factual knowledge. We were "guesstimating". We had stated in our proposal that this was the best estimate that we could make, but that we did not know whether we would finish up with this money or not.

Question: I am not talking about the contract price so much as the organizational relationship that you said the contract created with the Air Force.

Answer: As long as the Air Force paid the cost, they called the tune.

Question: For someone who does not talk to the Government daily, what does CPFF mean?

Answer: CPFF means "cost plus fixed fee". The fixed fee is determined on the basis of the original estimate of cost. They paid this fixed fee (2, 3, 4, 5, 10%, whatever it is) based on the original estimate. If the costs are higher you don't get an increase in the fee, you get only increase in the cost.

Question: Were you the sole bidder on this particular program, or was it negotiated with you, or did you go into competition with anyone?

Answer: We were in competition. The evaluation was done first on the basis of engineering merits of the bid, and the experience. In spite of the fact that we had only one or two experienced people in our branch of the organization, we had just about one or two more experienced people than anyone else in the business. So, we received the assignment for the majority of the presses. However, other orders, including educational orders, were given to other organizations. They built the presses and those presses are operating

There is the 50,000 ton press built by Mesta Machine Company in Cleveland, Ohio at the Aluminum Company of America. There is a 35,000 ton press in that plant built by United Engineering & Foundry; there is a 12,000 ton extrusion press built by Lombard at Harvey Machine Company. The rest of the program was handled by us.

Question: Are the engineering details confidential?

Answer: I do not know how Loewy-Hydropress handles this matter now, but, as far as I am concerned and, of course, the Engineering Supervision Company, we have very few "secrets." We follow the policy of releasing to the entire industry information that we accumulate. If you want to see the most spectacular photoelastic model that has been built to Prof. Gerard's and my knowledge, it is right now in the NYU laboratory. The model is a 50,000 ton press, installed at ALCOA in Cleveland. Engineering Supervision Company is studying the performance of this press and for that purpose we have built, with the assistance of the New York University, a photoelastic model that will be put into the oven tomorrow to get the tri-dimensional stress pattern. I recommend that whoever is interested in experimental stress analysis goes and looks at this press model now and then, later on, when the slides are made, looks at the slides. It is spectacular.

Question: Did you get the services of any of the German engineers who worked on the Heavy Press Program in Germany during the War?

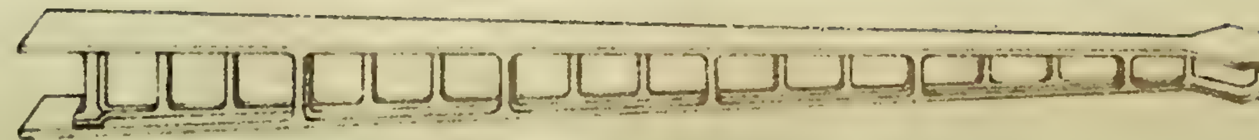
Answer: Yes, the two men I mentioned before, who knew something about heavy presses, came from Germany. They were the engineers who built the heavy presses in Germany. The 15,000 metric ton and the 30,000 metric ton German forging presses, the 12,000 ton and some other extrusion

presses were designed by them. These two men were with us. The reason for their being so strongly in favor of the simplicity of elements on our forging presses was that on the 30,000 ton German press they had trouble with the elements of the press. They had, for instance, failure of two press beds before the third press bed was so designed that it would stand up. The reason for the failures on the two press beds was caused by the difficulty in stress analyzing the casting which was an extremely complicated one. They said, "Let's make it so simple that we know exactly how high the stresses are, where the stress concentrations are, and so on." So that was the principle we applied. Today, it would be differen If you asked me whether I would use this laminate design in designing heavy presses today, I would have to think it over very carefully before giving an answer. Why? Because today we know immeasurably more about stress distribution in press elements and press details than we knew at that time. Today, we know that if we have to design a part that looks "out of this world", and we are not certain about the stress distribution, we can put it through photoelastic analysis or through model analysis, and we will know the stresses. At that time people were designing presses without making stress analysis. Some o the press builders said at that time that stress analysis was for people who did not have sufficien experience in press designing. I am not exaggerating, I am quoting. My answer was that at least I have the advantage of knowing when I don't know something and trying to find the answer. This refusal to take nothing for granted preserved us in this program from a tremendous amount of failures. We are not perfect, we are not angels, we are not saints. We have had failures and we will have failures on our machines. Some of the elements do not perform satisfactorily and have t

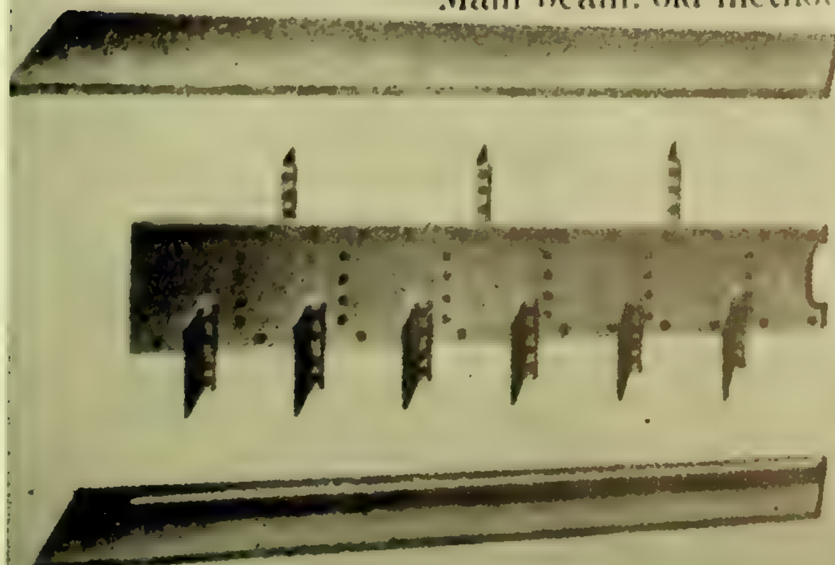
be modified, but the cost, the value, and the delays caused by those modifications are insignificant by comparison with failures which happen on heavy presses that are not as thoroughly analyzed and carefully watched in design and manufacturing as we have done. Any responsible engineering executive must be aware of the limitations of human experience and realize that if you don't know something you can find the answer, if you look for it. But if you close your eyes, and say, "Well, I know everything and I don't need to know more than I know today", then, that's the end of it and you will never learn anything. In that respect, the best story that I know is of the man who met a stranger and they became very friendly. The stranger said that he had the power to grant the man one wish. The man thought this over and discussed it with the stranger - wealth, power, health, large family, knowledge, and all kinds of things. Then he said, "You know, actually, I am so happy and so satisfied with my situation today that I want only one thing. I want to remain as I am today, the rest of my life." The stranger looked at him and said, "All right, if that is your wish, it will be fulfilled." So the man shook hands with the stranger, went home and died that night. That was the only way for the stranger to keep his promise in fulfilling the wish. You cann live and not change. Life is change. If you cann learn something new every day, then you might just as well be dead. Following this philosophy, at Engineering Supervision Company have no des secrets, beyond the bidding stage, from anyone. For instance, it is not customary in the press bu ing industry to give detailed drawings to custome When <u>we</u> sell a machine we give a complete book drawings with it. We feel, first of all, that we couldn't keep the secrets longer than six months, anyway, and, if we can't learn and if we can't ma

the next machine better than the previous one, then we are not worth our reputation. We have the reputation of being good designers. So, we should be able to keep our place on top of the heap by living up to our reputation, not by resorting to silly secrecy. We are proud of the fact that we can count the vast majority of our competitors among our friends.

Again, thanks a lot for your attention.



Main beam: old method



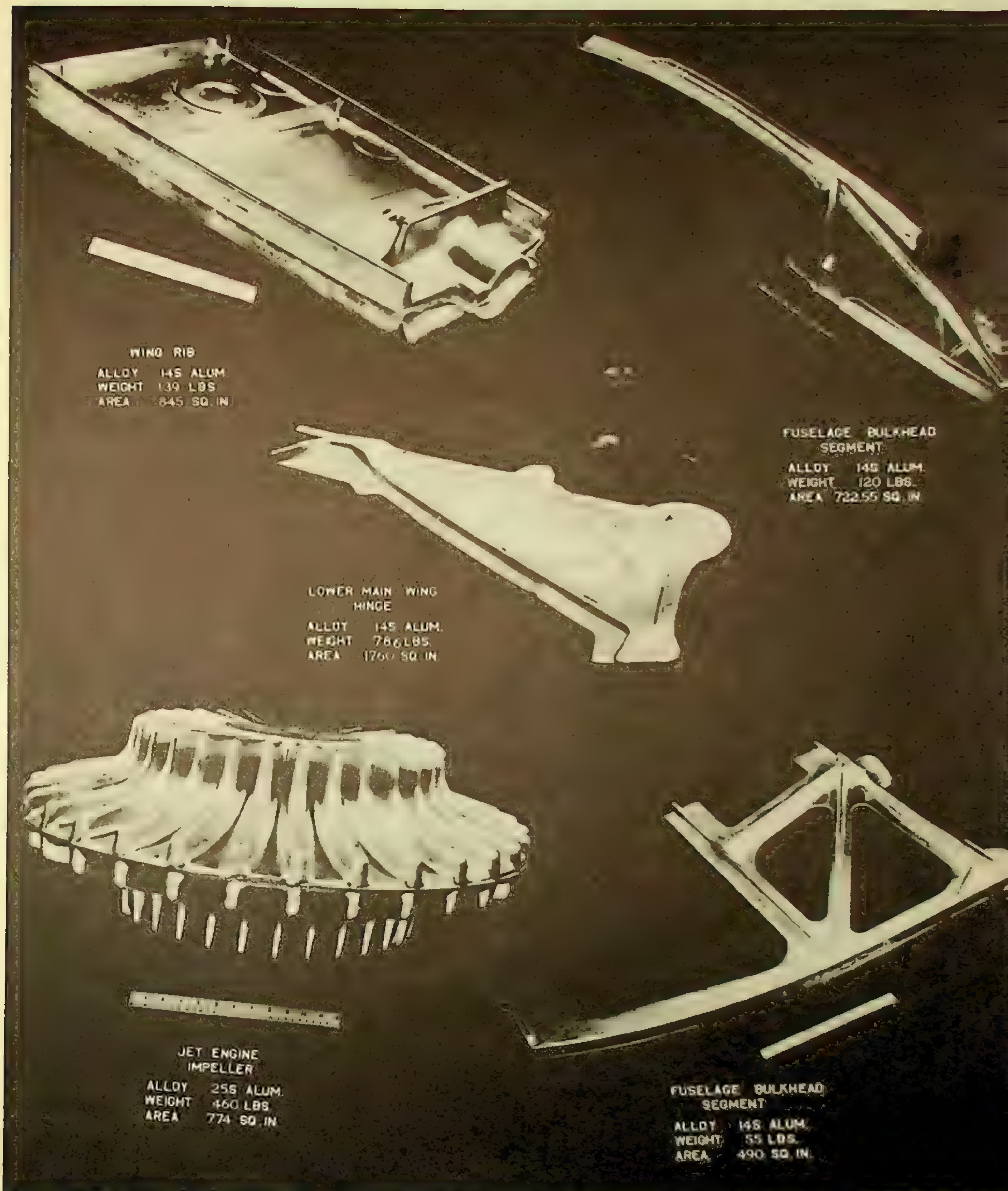
Main beam: forged

One wing beam, or spar, of a World War II Republic P-47 (detail, above left) contained about thirty pieces, scores of rivets, and took ninety-two hours to build. Today's cost: $580. Forged in one piece (detail, above right) it might cost under $250. Existing U.S. presses are far too small for jobs like this.

Courtesy of FORTUNE Magazine

Slide #1

Slide #2



LOEWY-HYDROPRESS ARCHIVE

AIRCRAFT FORGINGS
Courtesy of Wyman-Gordon Co.

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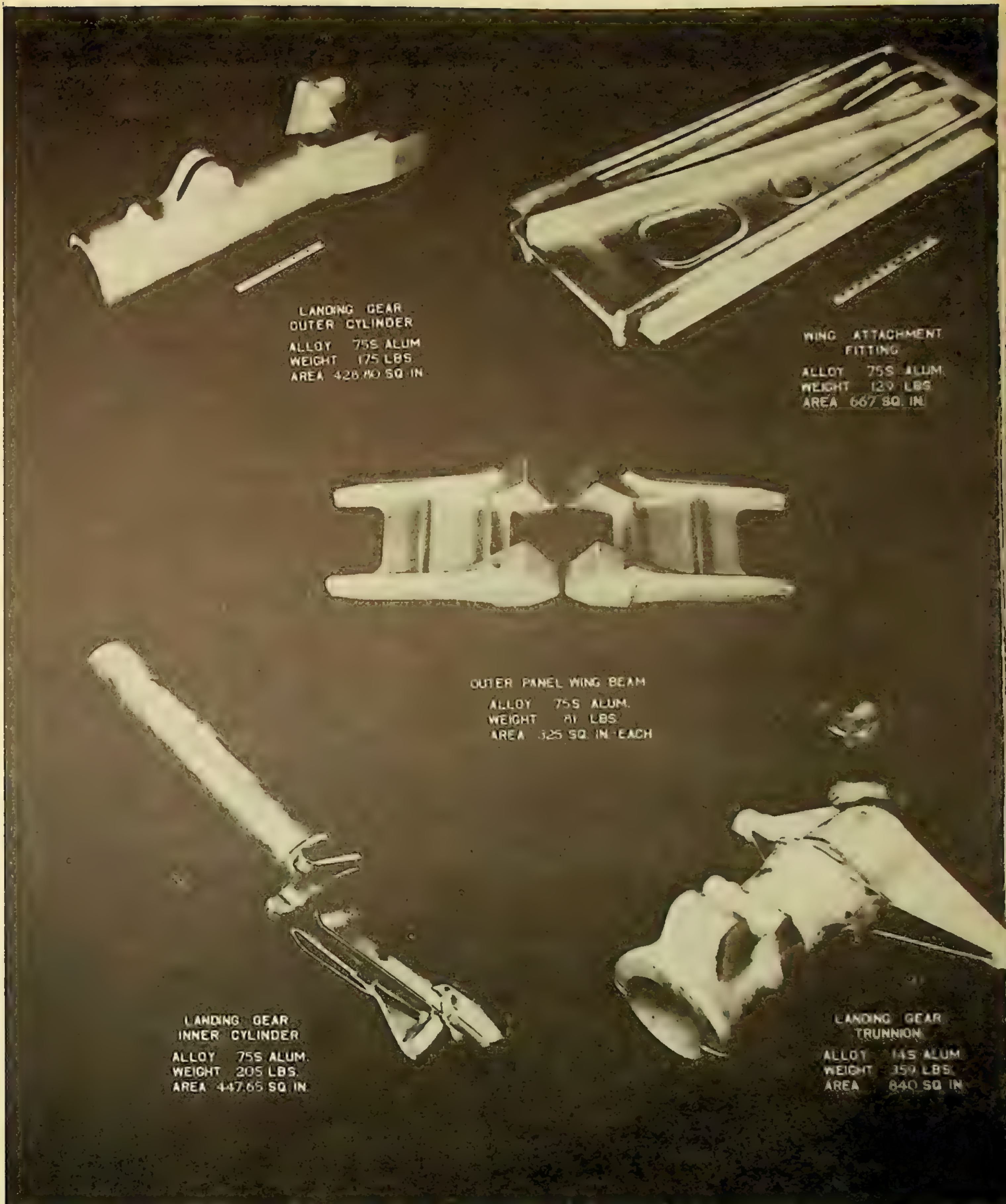
Slide #3



LOEWY-HYDROPRESS
ARCHIVE

AIRCRAFT FORGINGS
Courtesy of Wyman-Gordon Co.

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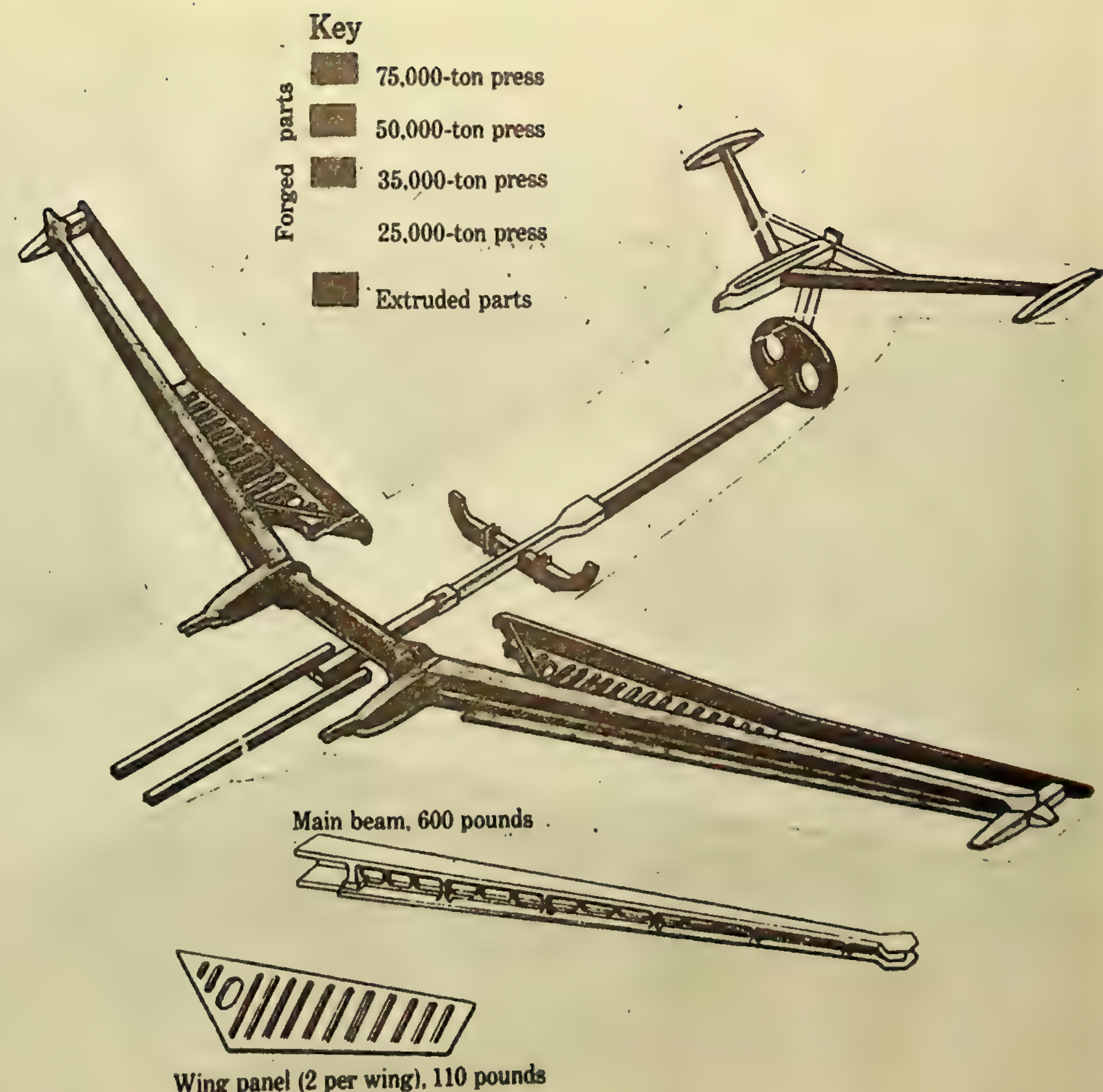

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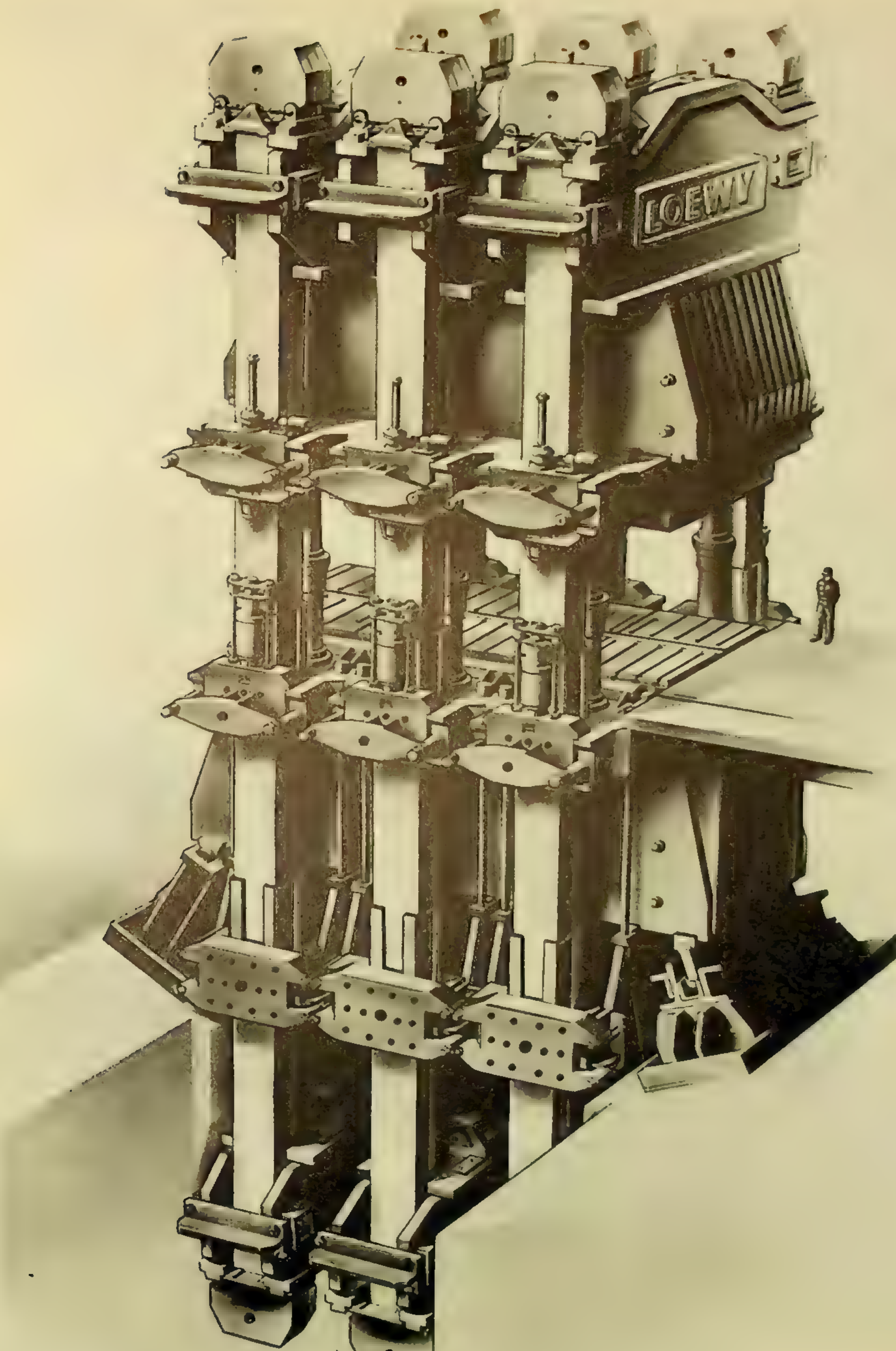

LOEWY-HYDROPRESS

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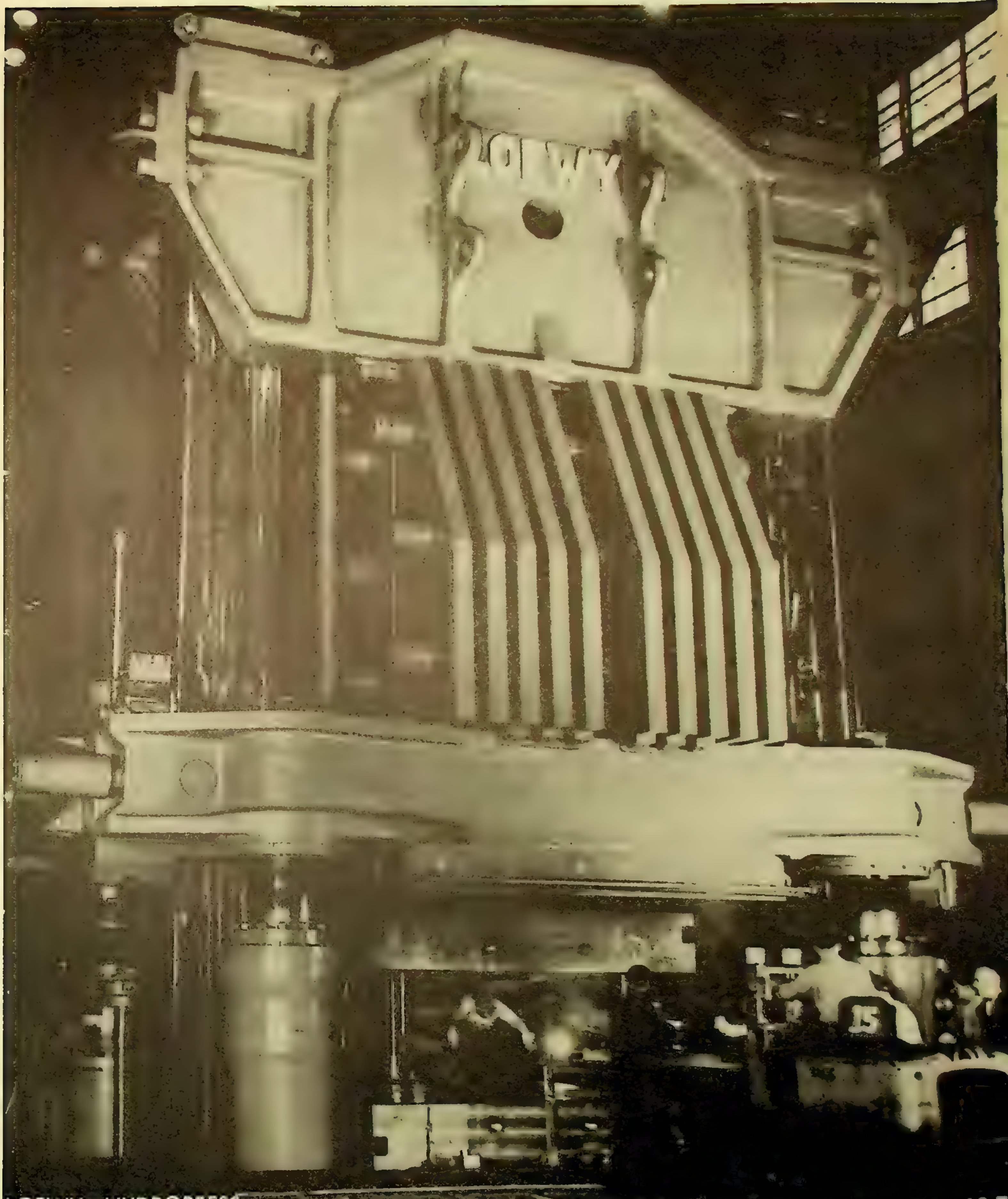
Slide #7



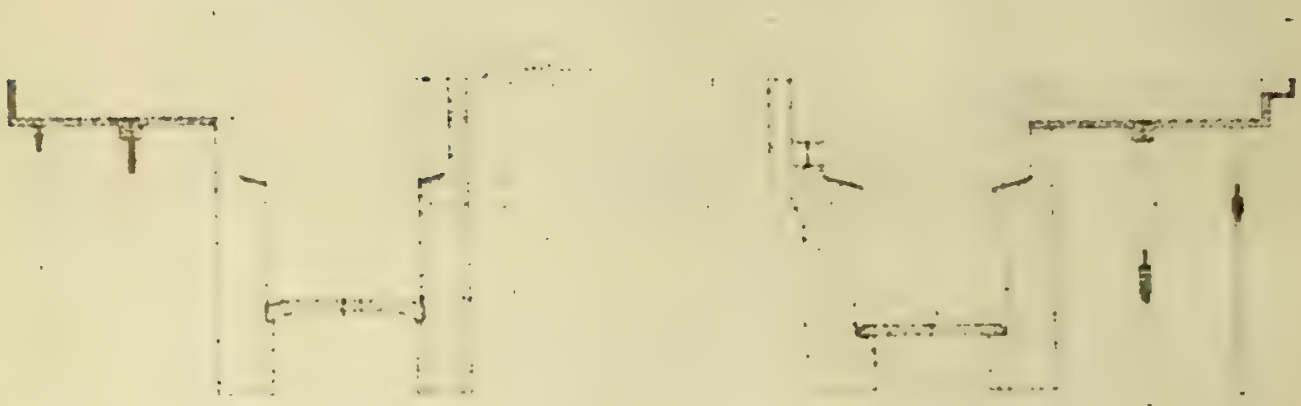
Slide #8

FOUNDATION

FOR 50 000 AND 35 000 TON PRESSES

"MAJOR" AND "MINOR"

AND ACCUMULATOR STATION "ACCUPLUS"



Site

THE WYMAN GORDON COMPANY

NORTH GRAFTON MASS

Excavation

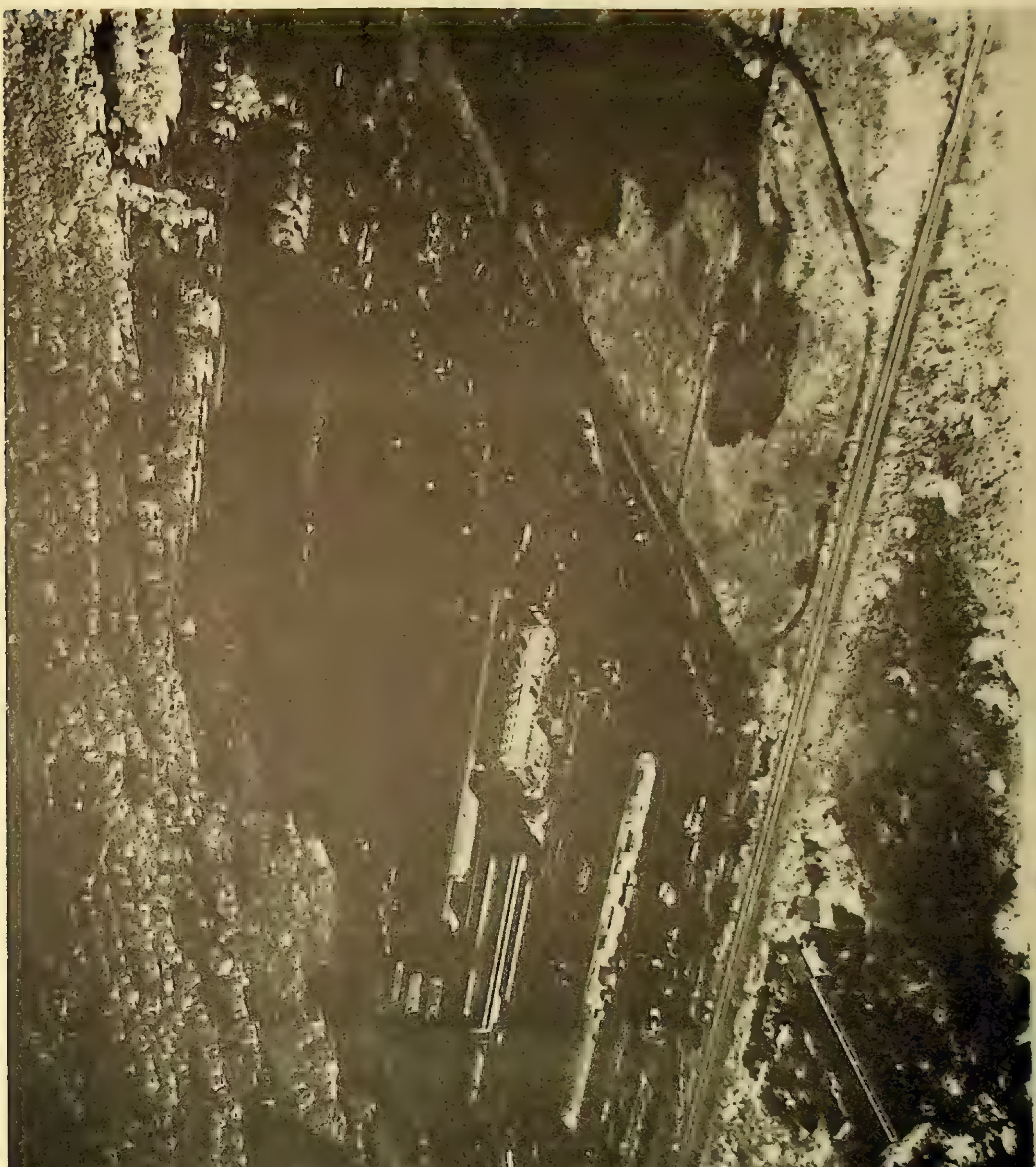
DEPTH	110 ft
SOIL & ROCK EXCAVATED	129 600 cu yds

Foundation

*DEPTH—MAXIMUM		90 ft
*DEPTH TO PIT FLOOR	MAJOR	75½ ft
	MINOR	69½ ft
	ACCUPLUS	13½ ft
TOTAL PLAN AREA OF FOUNDATION		33 300 sq ft
MAXIMUM PIT WALL THICKNESS		13 ft
CONCRETE POURED		22 900 cu yds
REINFORCING ROD		1 300 tons

*Depth measured from operating floor level

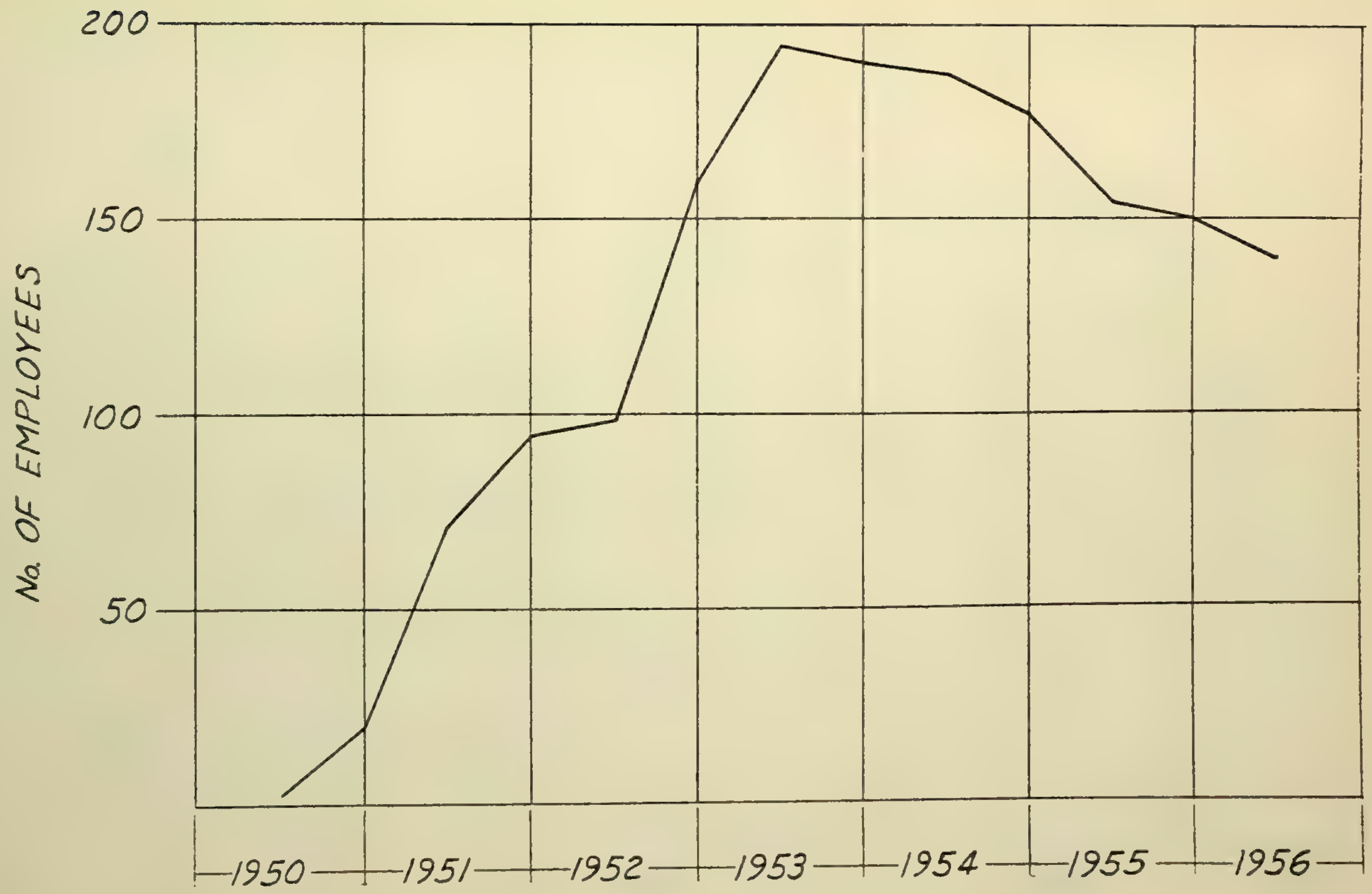
Slide #9



LOEWY-HYDROPRESS

WYMAN-GORDON PLANT, WORCESTER, MASS.
SHOWING CONSTRUCTION SITE FOR LOEWY

Slide #10



ESCO | HEAVY PRESS PROGRAM — PERSONNEL | 302

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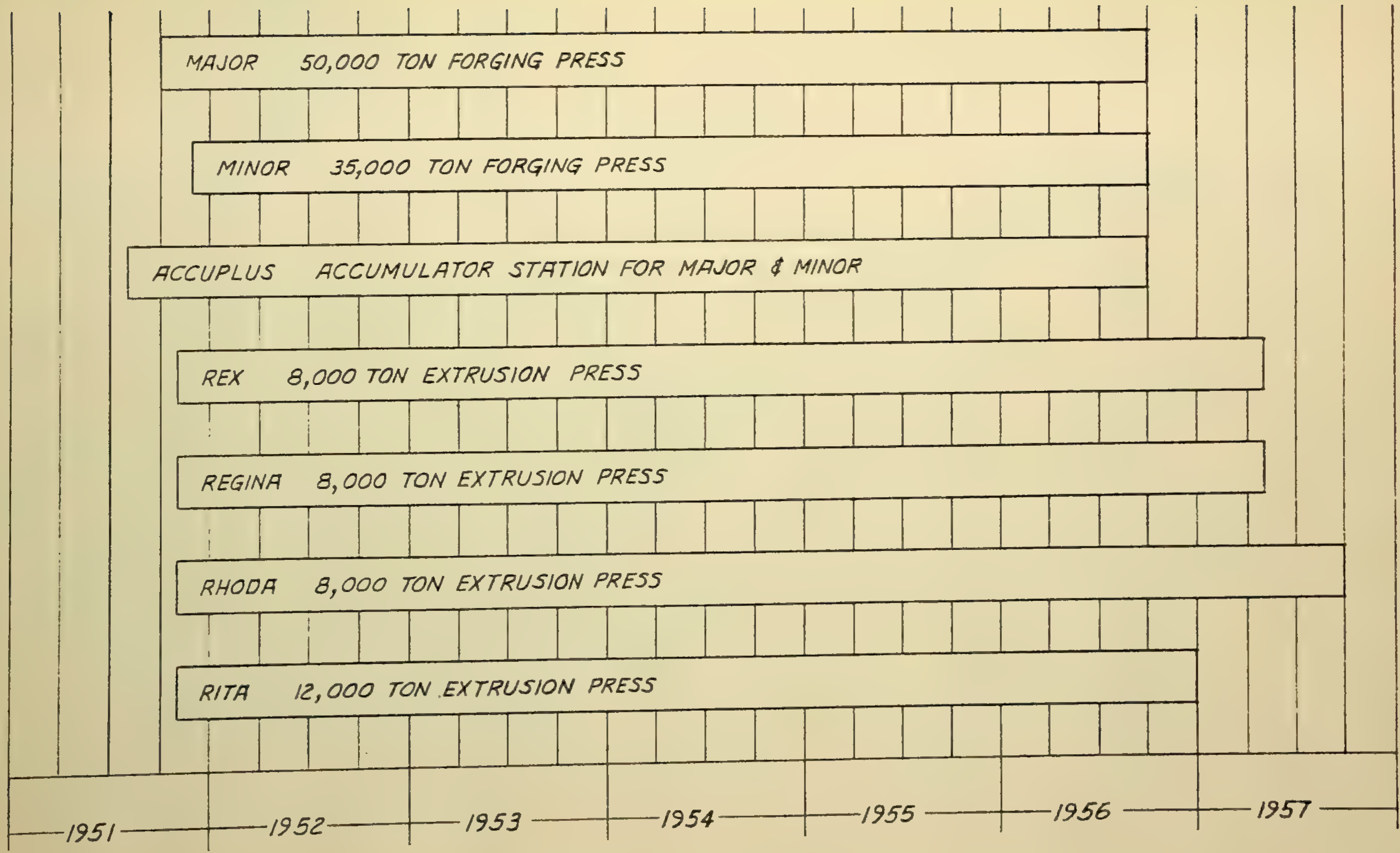

ESCO

HEAVY PRESS PROGRAM

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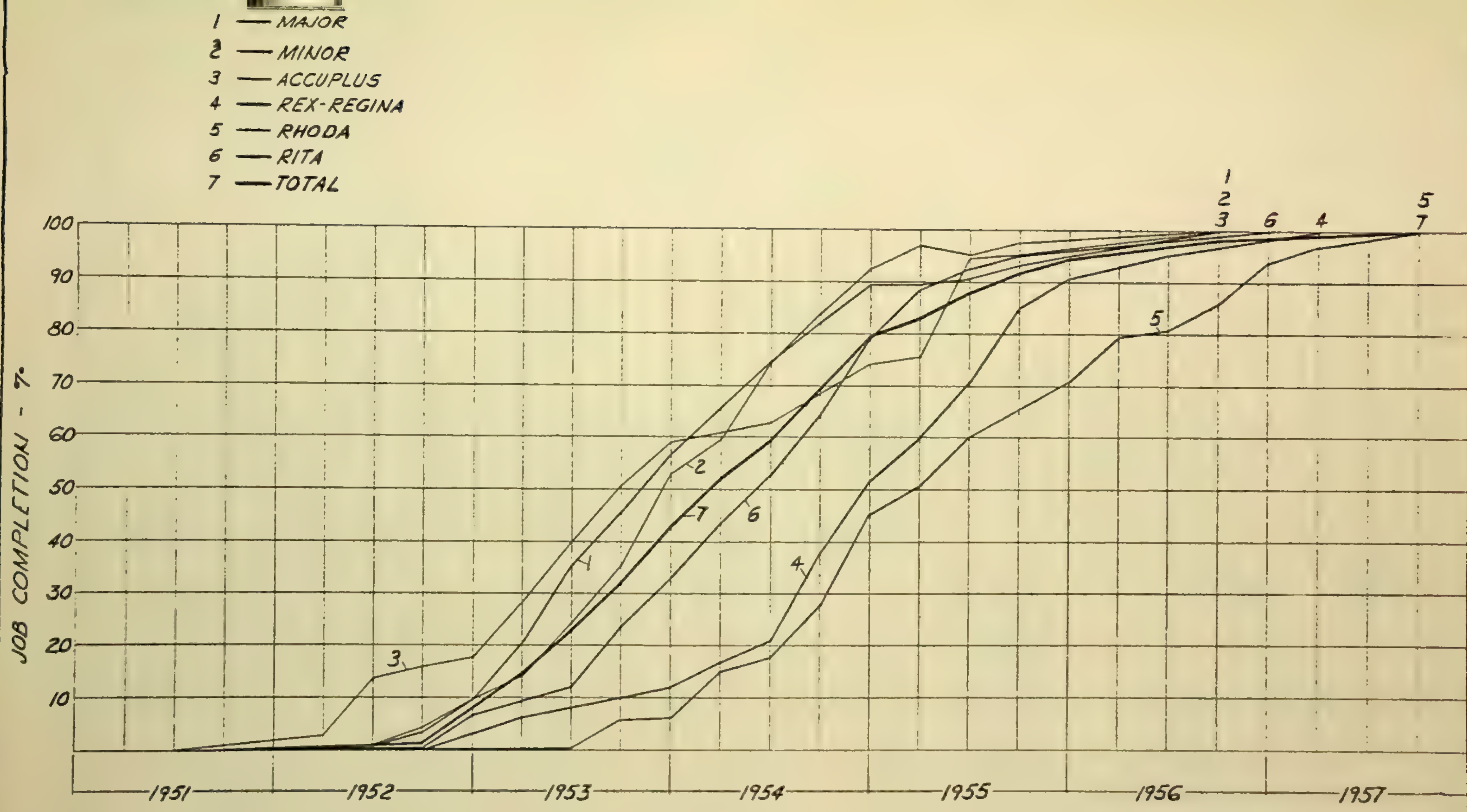

ESCO

HEAVY PRESS PROGRAM

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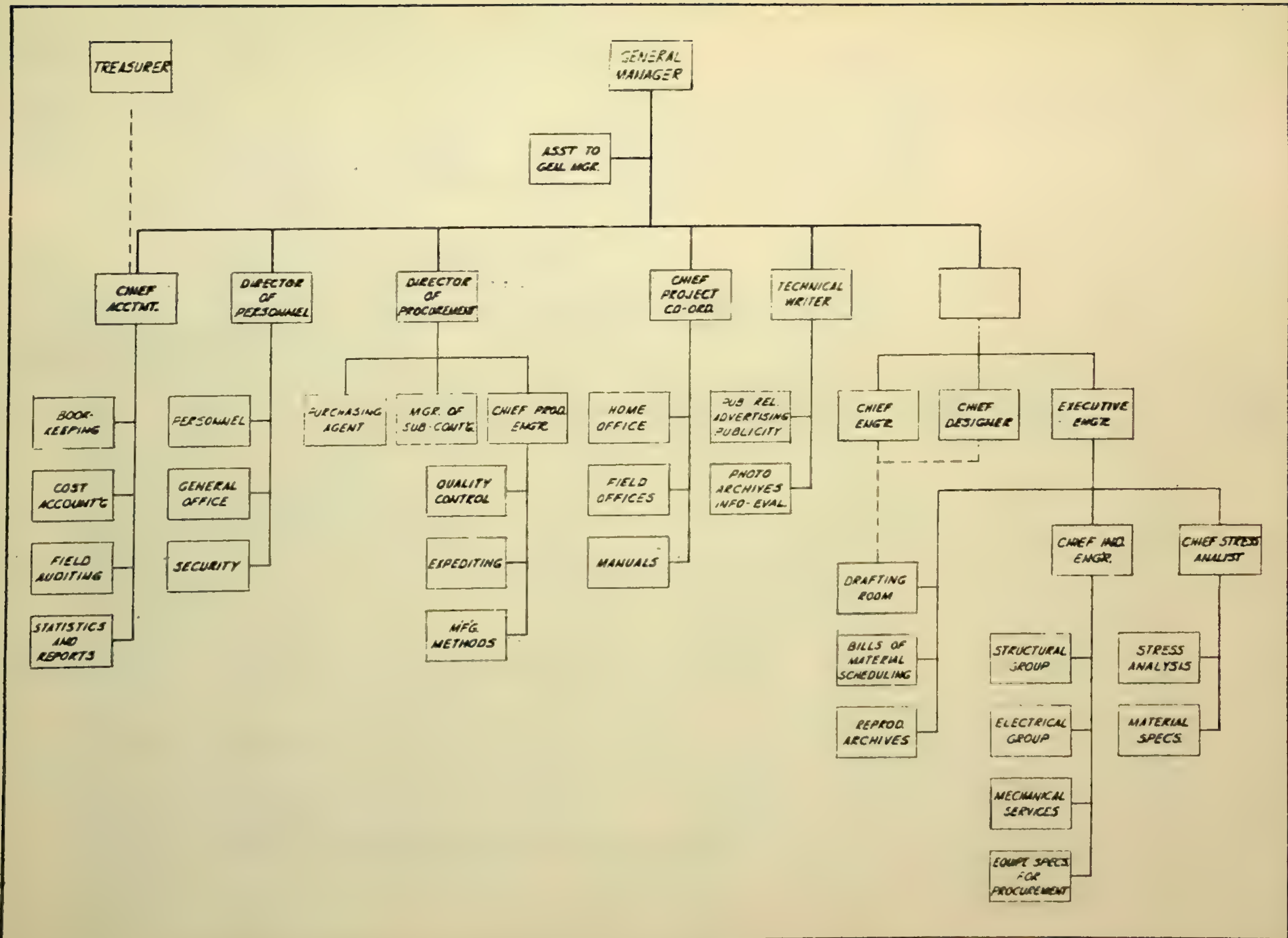

ESCO ARCHIVE	HEAVY PRESS PROGRAM FINAL ORGANIZATION CHART	301

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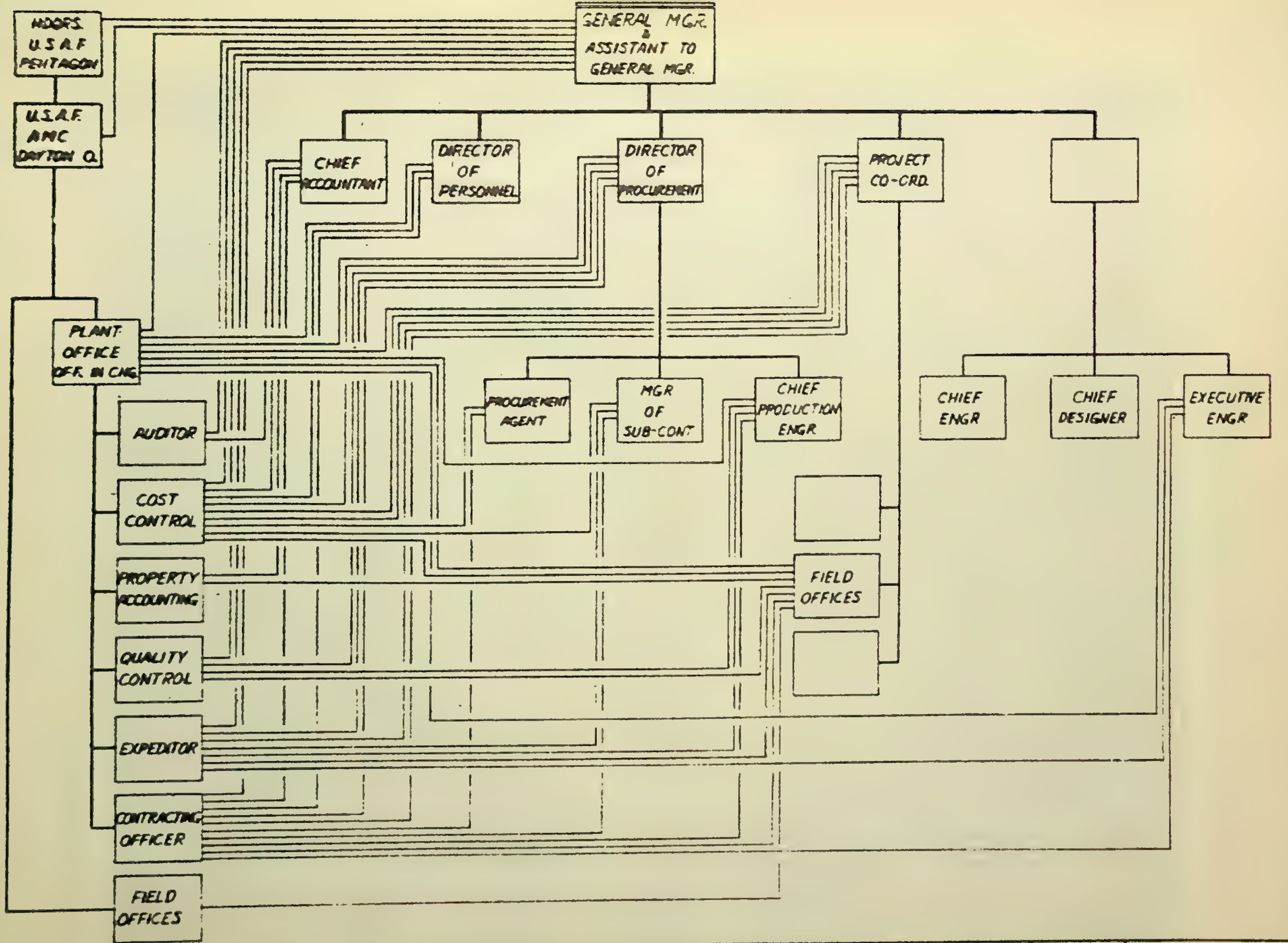

ESCO ARCHIVE

RELATION BETWEEN THE AIR FORCE $ PRIME - CONTRACTOR

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Slide #16

Slide #17

LOEWY—HYDROPRESS

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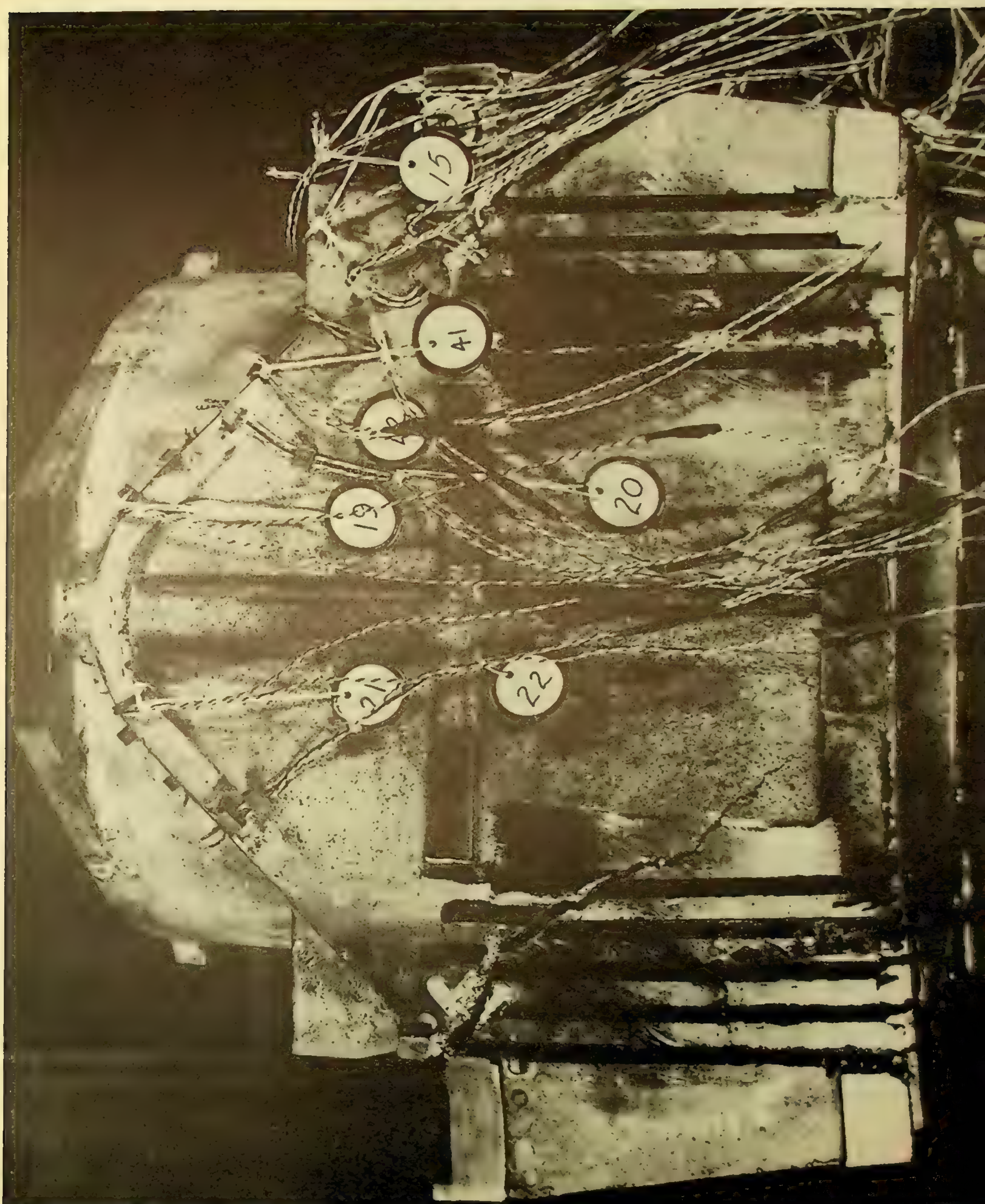
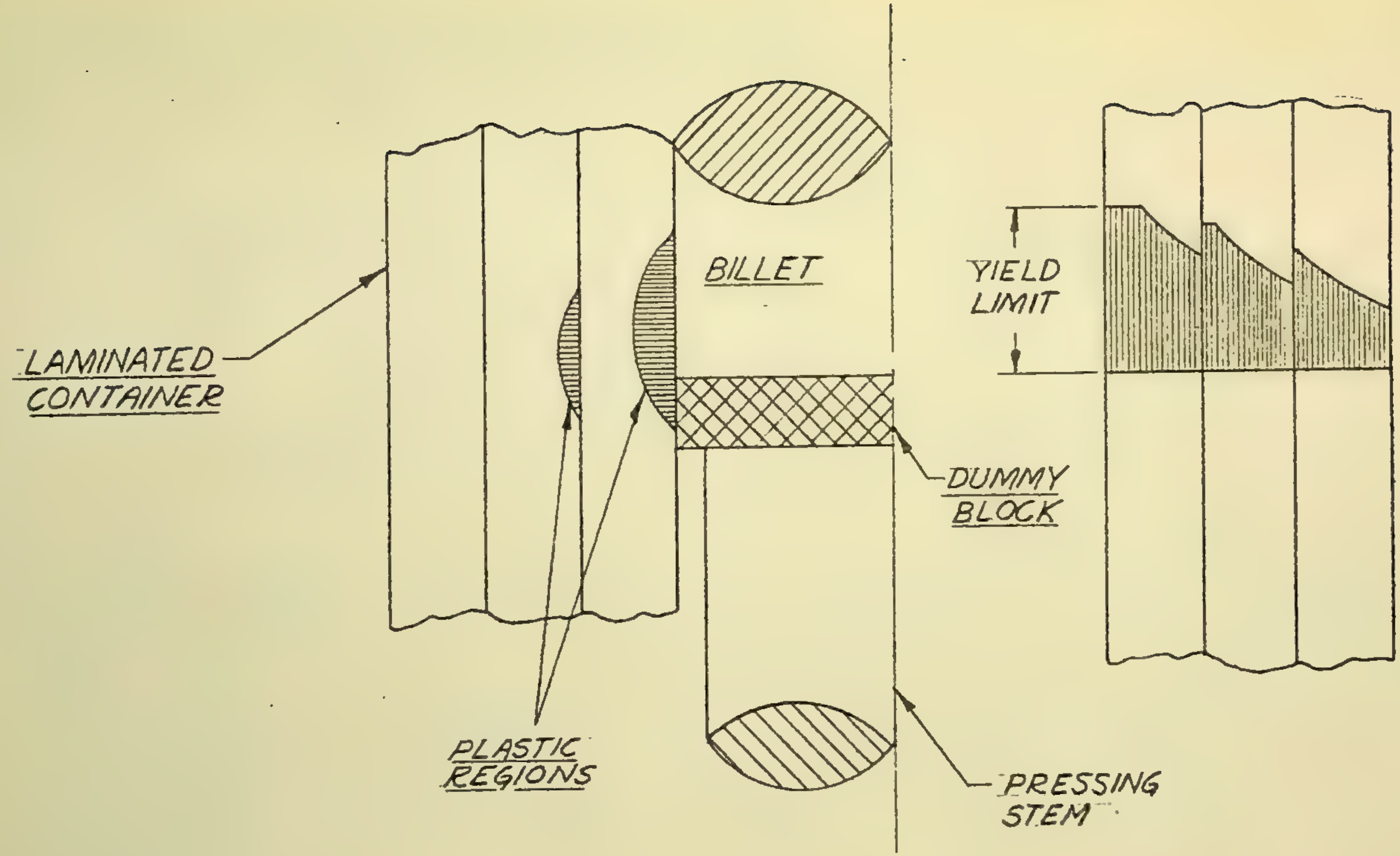


Slide #19


MULTIPLE TUBE CONTAINER FOR LOEWY
12,000 TON EXTRUSION PRESS
LOEWY-HYDROPRESS
ARCHIVE

Slide #20



CONTAINER STRESSED BEYOND ELASTIC LIMIT

PLASTIC DEFORMATION OF CONTAINER WHEN


EWY-HYDROPRESS
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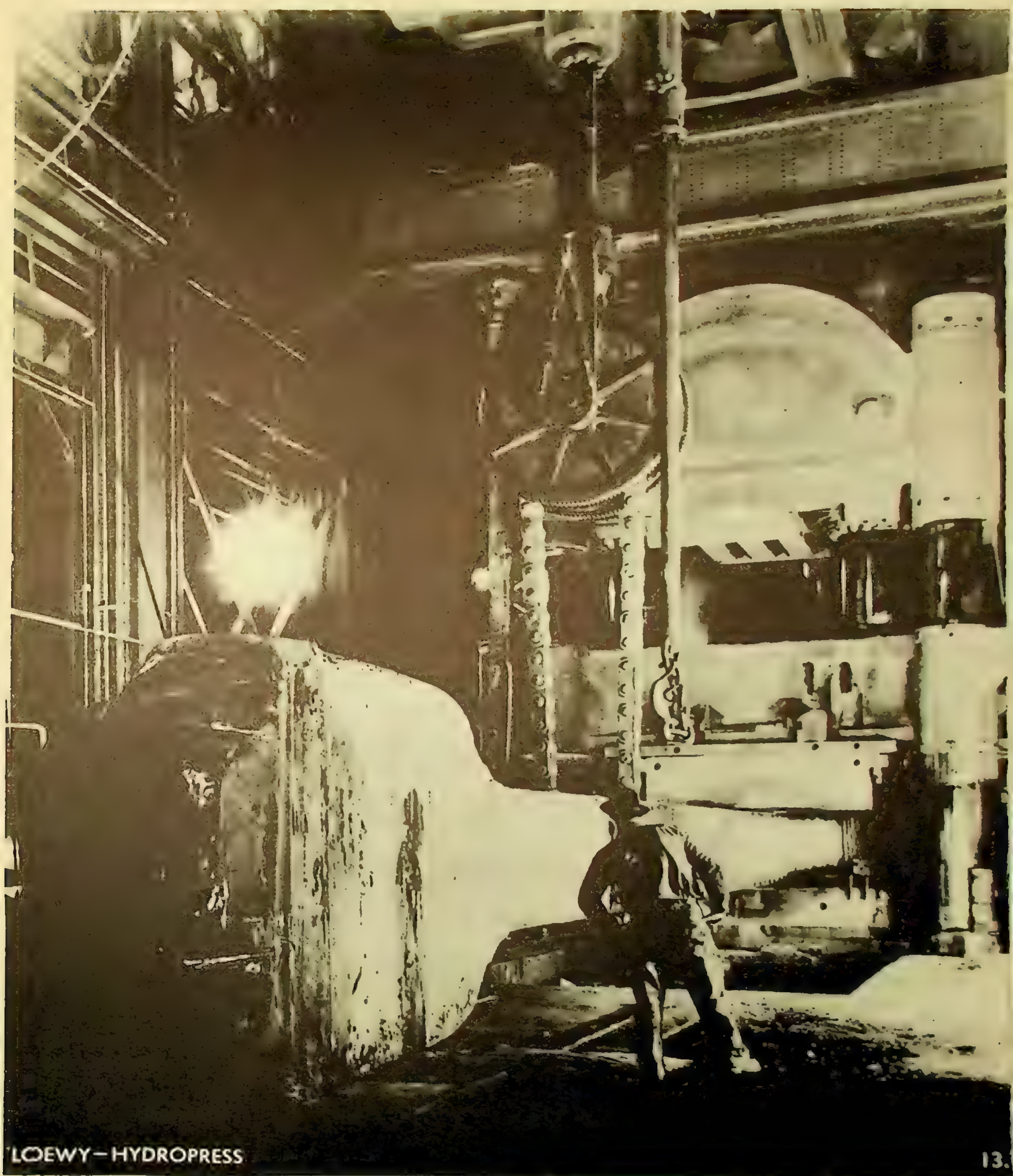

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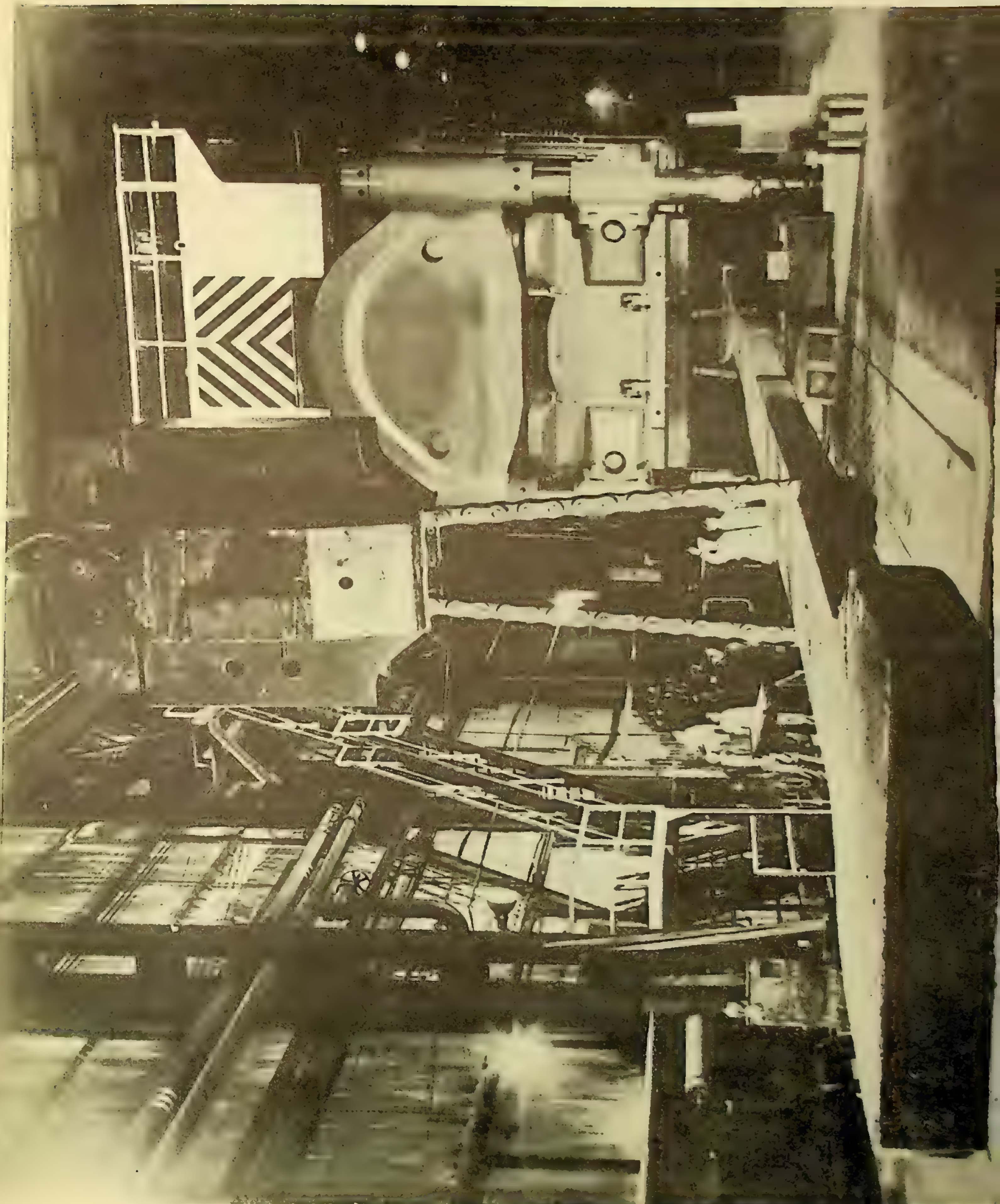

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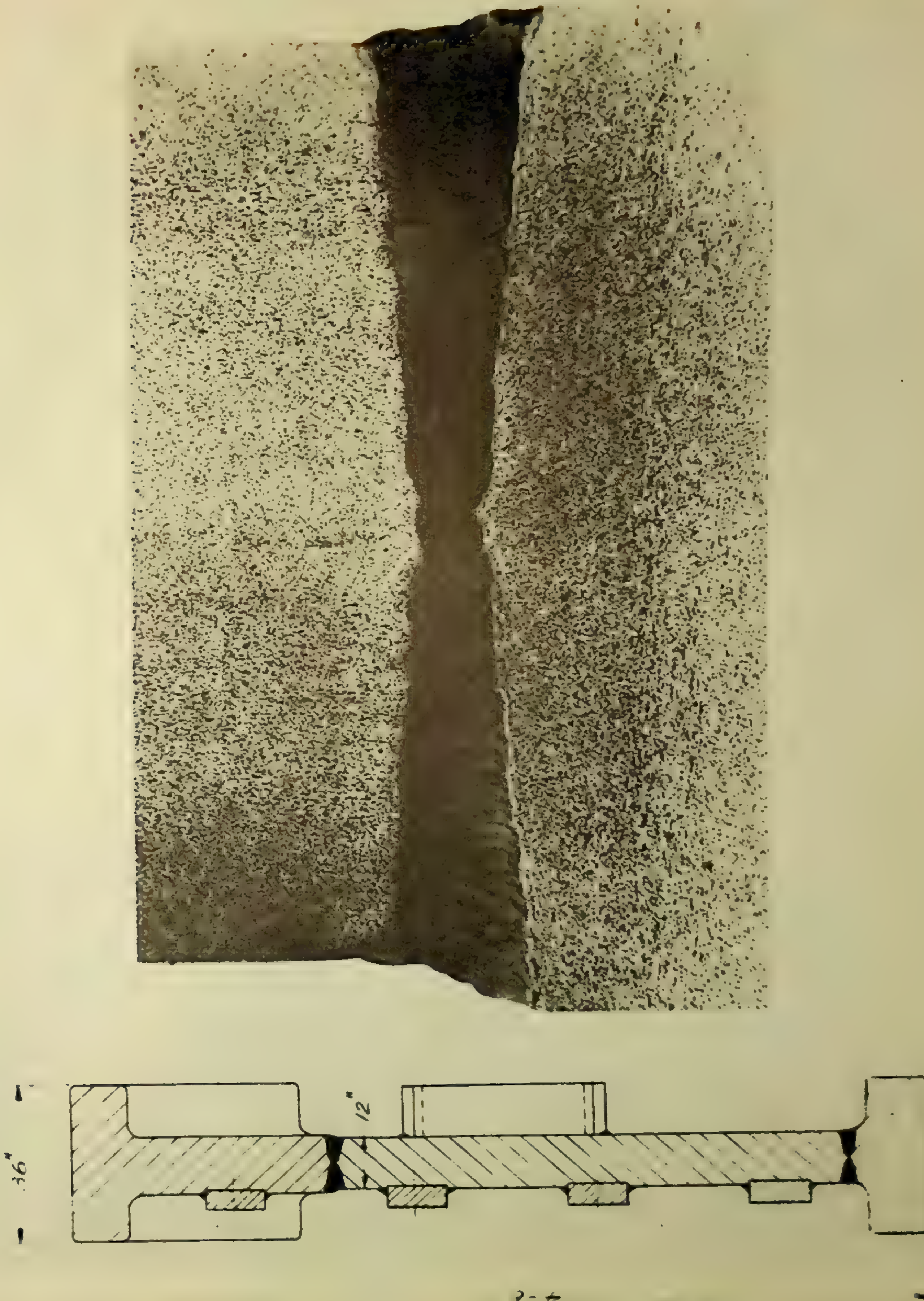

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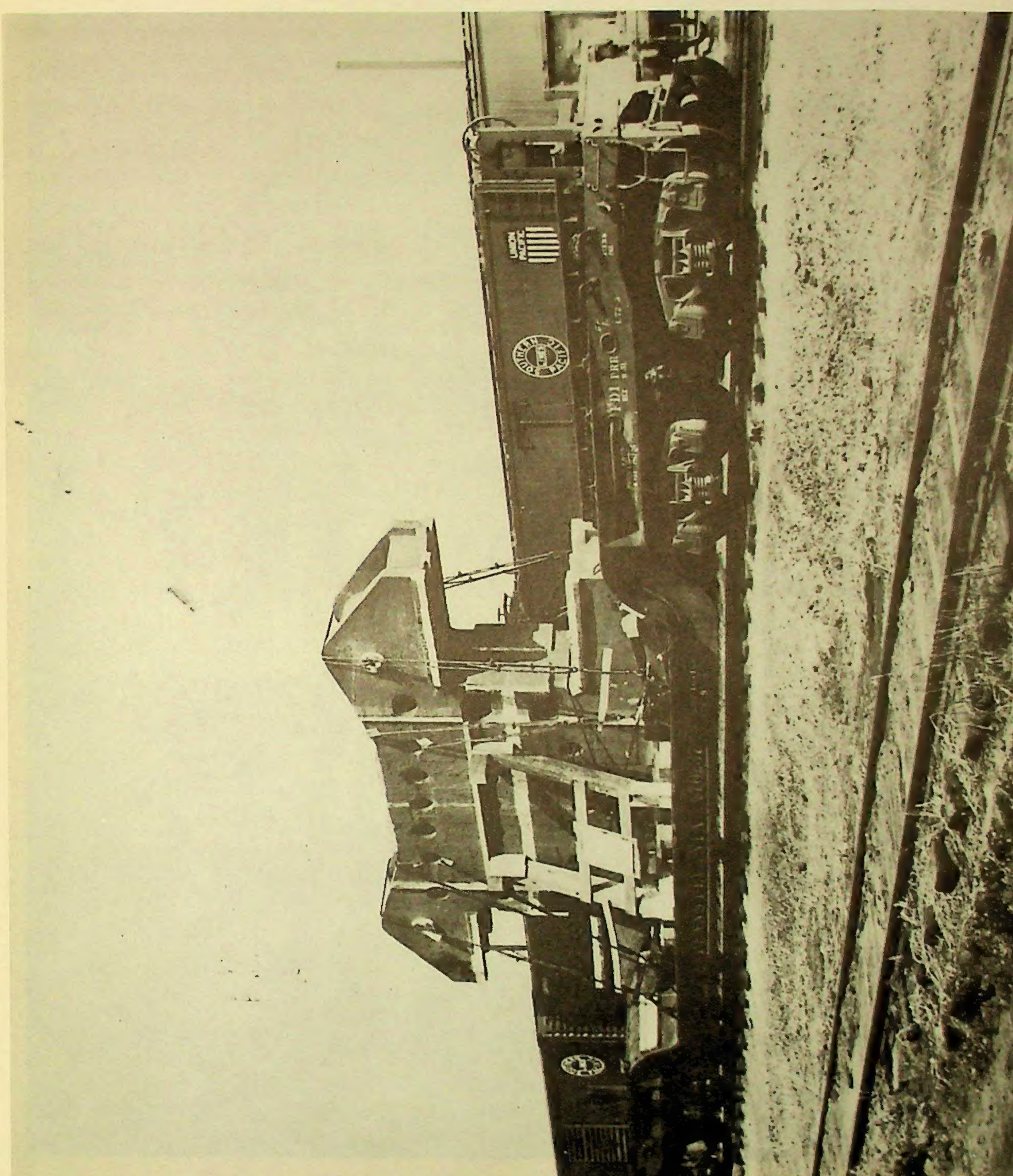

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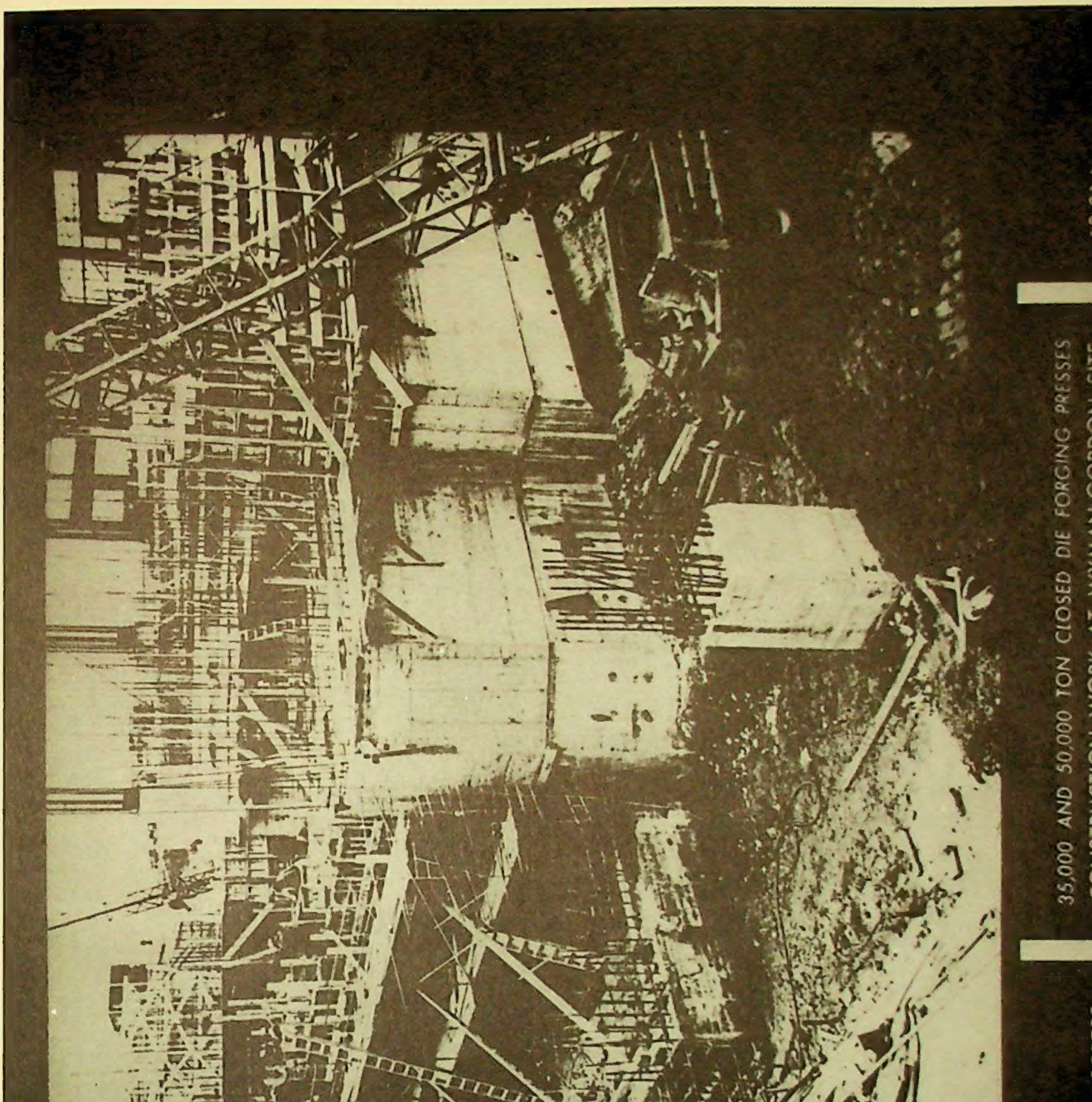

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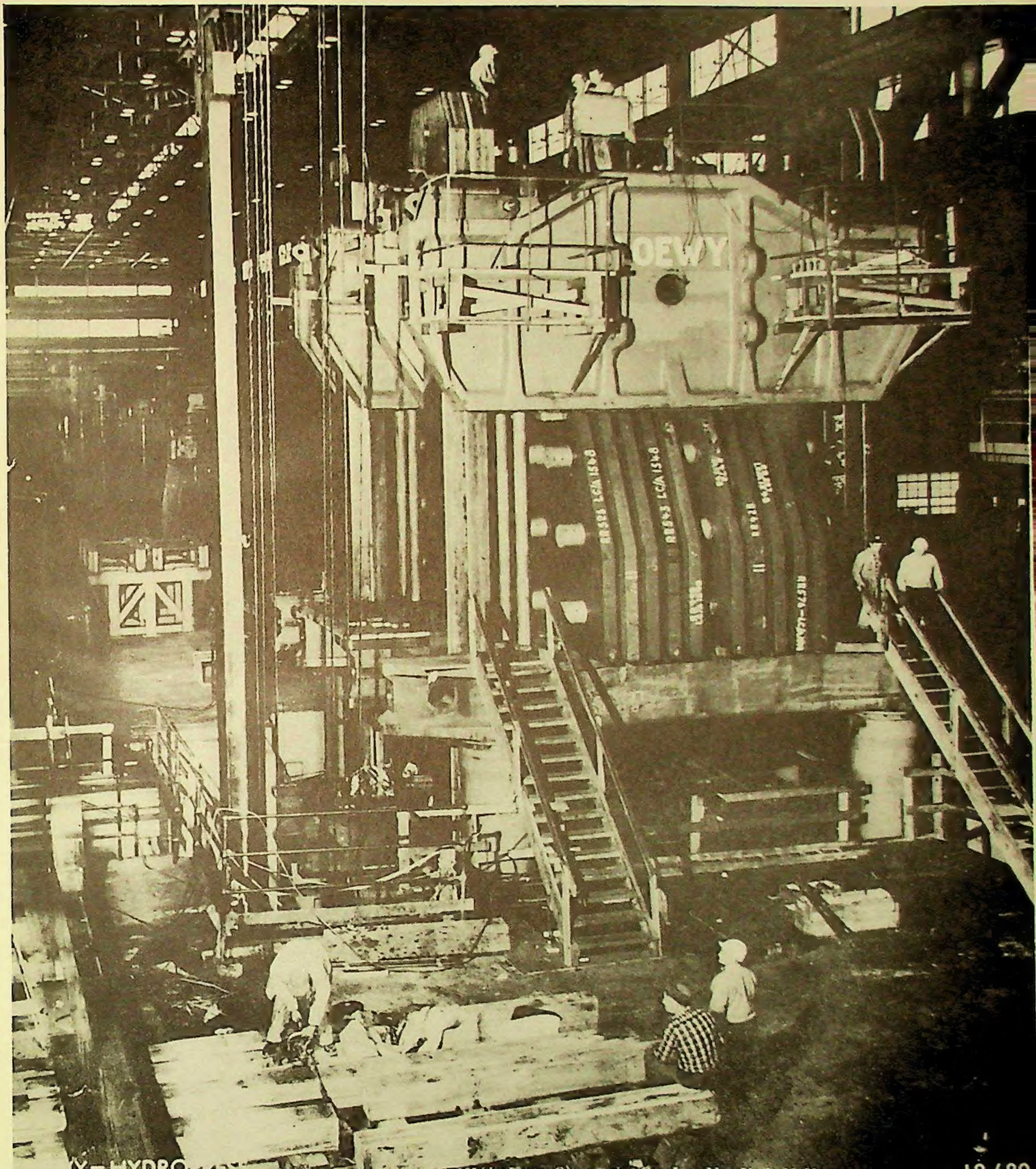
OEWY
Y — HYDRO
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Slide #29